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ROSE AND CARLESS

MANUAL OF SURGERY

SIR CECIL WAKELEY, BT K B E, C B

CONSULTING EDITOR

MICHAEL HARMER SELWYN TAYLOR

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WILLIAM ROSE

1847–1910

William Rose was the son of a doctor who practised for many years at High Wycombe in Buckinghamshire. He came to the Medical Faculty of King's College in 1867 and was subsequently a dresser to Sir William Fergusson. He obtained his first medical qualifications in 1871 and was thereafter house surgeon and Sambrooke Surgical Registrar, being appointed to the consulting staff of the hospital in 1876.

Rose was a skilful and dextrous operator, seen at his best when repairing a cleft palate and "hare" lip as it was then called. Affectionately known to his students as "Billy" he was a great lover of horses, a first rate whip and frequently drove a four in hand. His hospitality was boundless and his dinner parties famous. In addition to his papers on "hare" lip and cleft palate he wrote on the removal of the Gasserian ganglion for neuralgia. He became famous as an expert witness in railway accident compensation cases. For a short time Rose occupied the Chair of Surgery at King's College, this however he soon relinquished for the Professorship of Clinical Surgery. He was also a consulting surgeon to the Royal Free Hospital and retired from the honorary staff of King's in 1902.

ALBERT CARLESS

1863–1939

Albert Carless received his early education at King's College School, entering the Medical Department of King's College in 1881. He was industrious and brilliant, obtaining almost all the prizes which were offered. He qualified in 1885 and was subsequently house surgeon and Sambrooke Surgical Registrar, eventually joining the staff of the hospital in 1889.

Carless excelled as a teacher and in his earlier days was a successful tutor for the F.R.C.S. examination. He served in the Army Medical Service during the 1914–1918 War. In 1902 Carless succeeded Watson Cheyne as Professor of Surgery in King's College and held the Chair of Surgery until 1918. He resigned as Senior Surgeon to King's College Hospital in 1919.

It was Carless who wrote the greater part of the original *Manual of Surgery* and subsequently saw it through many of its early editions. He also had the satisfaction of seeing it appear in Hungarian, Chinese, Arabic and American editions.



TO

LORD LISTER, LL D , F R S

PRESIDENT OF THE ROYAL SOCIETY,

THE FATHER OF ANTISEPTIC SURGERY,

THIS WORK IS, WITH PERMISSION,

DEDICATED BY THE AUTHORS

IN GRATEFUL ACKNOWLEDGMENT

OF THE MANY ADVANTAGES THEY HAVE DERIVED

WHILST ASSOCIATED WITH HIM IN HIS WORK

AT KING'S COLLEGE HOSPITAL

This dedication originally appeared in the first edition in 1898

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COLOUR PLATES

ACKNOWLEDGMENTS

The editors have pleasure in acknowledging the great help which they have received from a number of people.

In any text book which goes through many editions there must remain, in spite of re-writing, some of the work of former contributors. The present editors therefore pay their tribute to these men, and in particular to Dr F. S. Cooksey, Mr A. J. Heriot and Professor H. A. Magnus.

Most of the new clinical photographs were made either by Mr W. Smith in the Department of Photography at King's College Hospital or by Miss J. Hunt in the Department of Medical Photography at the Royal Marsden Hospital. Miss Hewland and Mr R. Young executed most of the new drawings.

The index has been compiled by Mr Eric Sturdy, F.R.C.S.

Acknowledgment is also made to Mr Leon Gillis for Figs. 12.10 and 12.11, to the Editor and publishers of the *British Journal of Surgery* for Fig. 25.10, to Mr L. Cotton for Figs. 37.2 and 37.3, and to Dr A. Cannon and the *Annals of Tropical Medicine and Parasitology* for Fig. 41.2.

FOREWORD

I am pleased to write a foreword to the nineteenth edition of *Rose and Carless* for my association with this well known manual of surgery began some fifty years ago when I was a medical student at King's College Hospital I was fortunate enough to be house surgeon to the late Albert Carless one of the outstanding surgical teachers of this century and I owe much to this great man for in many respects he was my father in surgery After the First World War Carless asked me if I would help him with the eleventh edition of the book I readily agreed and I spent much time and energy in fully revising that edition which appeared in 1924 The twelfth edition appeared in 1927 and as Carless had by then retired from active surgery I asked my colleague John Hunter to help me with the thirteenth edition published in 1930 for I firmly believe that for a text book such as *Rose and Carless* two editors are better than one John Hunter and I edited the fourteenth fifteenth sixteenth and seventeenth editions of this work the seventeenth edition appearing in 1943

The untimely death of John Hunter in 1951 forced me to carry through the eighteenth edition single-handed and the work was published in 1952. I was at this time President of the Royal College of Surgeons of England and my spare time was very limited I therefore enlisted the help of my colleagues at King's College Hospital and elsewhere to write special chapters in the book This feature has I am glad to say been adopted again in the present edition for help in the production of which the editors have called upon the services of fifteen contributors

I have known both the present editors for many years and I am confident that in their capable hands this fine text book of surgery will continue in its high standard and will prove, as it has done for more than sixty years, a guide, philosopher and friend not only to the student but also to the practitioner

CECIL WAKELEY

73 Portland Place
LONDON W I
January 1960

PREFACE

There can be few text books in common use today which first saw the light in 1898 but *Rose and Carless* planned their work so well that it is still hard to imagine any medical library which could be considered complete without this familiar volume In this the nineteenth edition, we have repaired what we consider a signal omission in the past by introducing a brief biography of the two original authors of this work and we have retained their original dedication to Lord Lister

The seven years which have elapsed since the last edition of this book appeared have been exciting ones in almost all branches of surgery and for this reason, with few exceptions, the whole book has been rewritten This has also necessitated the introduction of some 370 new illustrations.

Advances in the knowledge of electrolytic disturbances and in chemotherapy are as fully covered as is possible in such a rapidly expanding field There are new chapters devoted to malignant disease the endocrine glands and pædiatric surgery In particular the sections on orthopædic surgery the surgery of the nervous system and the surgery of the alimentary tract have been re-designed in a more logical form Inevitably much has had to be deleted in order to keep the book of a reasonable size and the chapter on anæsthesia is the chief casualty We feel that this is now a subject in its own right for which a special text book should be consulted

In producing this book we have had the wise counsel and advice of Sir Cecil Wakeley who has seen so many previous editions through the press In addition we have had the assistance of fifteen contributors whose names will be found on page v and also at the beginning of each section of the book to which they have contributed It has been a long and difficult task producing the nineteenth edition and it would not have been possible without the help and guidance of a great many people some of whom are mentioned on page xi There is one however who must be mentioned here, Mr Dennis Tindall, of Baillière Tindall & Cox Ltd., for without his assistance and never failing good humour this work would never have been completed.

Lastly the editors hope that the decision to publish the book in one volume will commend itself to the reader

MICHAEL HARMER
SELWYN TAYLOR.

LONDON
January 1960

Section One

GENERAL CONSIDERATIONS

A C CUNLIFFE WILLIAM M DAVIDSON
C H GRAY MICHAEL HARMER
SELWYN TAYLOR SIR CECIL WAKELEY
A B WALLACE

Chapter 1

SURGICAL INFECTIVE DISEASES

General Principles

A sound knowledge of the processes of infective disease is of fundamental importance to the surgeon since many surgical diseases are from the onset bacterial infections and many others result from the entrance of bacteria into the tissues through wounds The surgeon has no need for a detailed knowledge of bacteriology the identification of individual bacteria can be left to the bacteriologist He must however be familiar with the types of disease associated with the organisms commonly found in surgical infections and with the natural history of these infections for without this knowledge he will certainly be unable to understand fully the clinical picture and treatment of infective diseases, to make full use of the laboratory in the diagnosis of these diseases, or to follow intelligently the "aseptic" operative techniques, or take steps to prevent the spread of infection should it occur For this very necessary background the reader is referred to the text books of medical bacteriology we shall confine ourselves to the more general considerations of the subject in so far as they are referable to surgical practice.

When pathogenic bacteria become established in the tissues of a susceptible host *infective disease* results the course of this disease, its symptoms and clinical signs, as well as the histological picture are the result of the interaction of the metabolic activity of the parasite on the one hand, with that of the tissues of the host on the other It is important to remember that the outcome of a disease is not dependant solely on the *virulence* or power of the parasite to produce disease, but on the *degree of virulence* in relation to the *resistance* of the host

Bacteria are often divided into those capable of producing disease, *pathogens* and those incapable, *saprophytes* Though these terms serve in many ways as very useful distinctions, it must be realized that these are only relative terms and that there is no hard and fast dividing line between the two Whereas there is no doubt that the spirochaete of syphilis and the diphtheria bacillus are pathogens and that *Bacillus subtilis* is a saprophyte, there are large numbers of bacteria whose position is more difficult to assess for example, the colon bacilli are normal inhabitants of the gut, but capable also of causing severe infections. It is well known that highly virulent organisms such as *Streptococcus pyogenes* may cause death in one patient while at the same time being harboured with impunity by another on the other hand overwhelming blood stream infections with organisms of as low a virulence as *B subtilis* are not unknown as terminal events in those debilitated by long illness. We explain these incidents by saying that the carrier of *Strep pyogenes* was highly resistant and that the resistance of the debilitated patients was very low

Many of these difficulties are solved if we define a pathogen as an organism capable of producing disease in an individual of average resistance With this definition *Strep viridans* would be considered as a saprophyte, but this would be quite compatible with its being the most frequent cause of subacute bacterial endocarditis, since it is well known that in the majority of these infections the resistance of the patient has been diminished by previous rheumatic valvulitis, or by congenital heart disease. There are many other organisms, *e g* the gas gangrene bacilli, which are capable in certain circumstances of giving rise to extremely serious disease but which are more frequently found as harmless contaminants.

Virulence. The property of *invasiveness* is one of the characters that distinguish one bacterial species from another or one strain from another within the same species. Since in many cases the pathogenicity of a particular micro-organism appears to be mainly determined by the relative rapidity of its spread within the tissues, it is logical enough to refer to those species which spread rapidly as *virulent* and to those which spread slowly or not at all as *avirulent* On the other hand, in a number of important diseases, *e g* tetanus and diphtheria, the causative organisms show little tendency to spread through the body but exert their lethal effect by the production, in localized foci, of powerful toxins. The virulence of bacteria, thus, cannot be equated in terms of invasiveness alone there are two factors concerned namely *invasiveness* and *toxicity*

With each pathogen the relative importance of these factors varies. Whereas the virulence of pneumococci and anthrax bacilli is related extremely closely to the rapidity with which the organisms spread through the tissues, in the virulence of many other bacteria, notably *Strep pyogenes* and *Clostridium welchii* (*perfringens*), both invasive and toxic factors are important. Even toxin producers like *Cl tetani* and *Corynebacterium diphtheriæ* have to establish themselves in the body before they can elaborate their toxins and therefore are possessed of some powers of invasiveness and though these are small compared with their powers of toxin production, their importance to the surgeon is undoubted the rationale for the *débridement* of wounds in the prevention of tetanus is to make conditions unsuitable for the germination and multiplication of tetanus bacilli it is on account of the invasive action of the diphtheria bacillus that tracheotomy has to be performed in obstructive laryngeal diphtheria.

Bacterial Toxins. The size of bacteria is such that, even in the severest infections, their physical presence alone would seldom be capable of harming the neighbouring body cells the effects they exert must be chemical. The term *toxin* is used to cover our ignorance as to the exact nature of substances that bring about these effects Some bacteria differ from the majority by producing in artificial cultures readily diffusible substances, *exotoxins* which give rise to poisonous effects in the absence of bacterial bodies (*e g* in filtrates) exotoxins are remarkable for the specificity of their action (*e g* erythrogenic toxin of *Strep pyogenes* for capillaries of the skin toxin of *Cl tetani* for nerve cells) and for their very high potency the amount of purified tetanus toxin required to kill a guinea pig is about 0·0005 ml. and that of *Cl botulinum* about 0·0001 ml

Exotoxins are, of course, not confined in their action to the production of specific effects in distant organs many probably play an important part in the local spread of the invading micro-organism. Thus the *leucocidins* and

fibrinolysins of *Strep pyogenes* and *Staphylococcus aureus* by damaging leucocytes and dissolving fibrin no doubt weaken the local defence mechanism and the proteolytic toxins such as *collagenase* possessed by some of the pathogenic clostridia probably influence considerably the character of the inflammatory reaction The α toxin or *lecithinase* of *Cl welchii* is worthy of special mention since its lethal necrotizing and hæmolytic actions can all be explained on the basis of the activity of this enzyme in "splitting" lecithin—a universally important cell constituent—and there is little doubt that this toxin is largely responsible for the local muscle damage as well as the toxæmia of *Cl welchii* gas gangrene The effect on infection of "*spreading factors*" has recently attracted much attention by hydrolysing hyaluronic acid one of the intercellular "ground substances" these hyaluronidases are said to enhance the spread of foreign material through the tissues Hyaluronidases are produced by many bacteria notably the staphylococci and clostridia, but their importance in disease is uncertain

The poisonous substances in the bacterial protoplasm are called *endotoxins* these are not readily liberated into fluid culture media and can usually only be obtained after disintegration of the bacterial bodies by such procedures as grinding, or repeated freezing and thawing When obtained in this way they are all relatively weak and non specific in their action The typhoid bacillus and gonococcus are organisms whose toxins are of this type and it should be noted that in contrast to tetanus and diphtheria, the clinical signs and symptoms of these infections are closely related to the distribution of the bacteria in the body

In general the knowledge derived from laboratory studies of bacterial toxins accords well with our clinical experience of infection in man

Types of Bacterial Infection. When bacteria gain access to living tissues, they may be destroyed or they may succeed in establishing themselves in the body the extent to which they multiply and spread through the tissues will depend not only on the characters of the micro-organism but on the type of response with which the body reacts to their presence. The resulting disease may be *local* or *generalized* The characters of the local infection vary greatly from acute and progressive inflammatory reactions, such as streptococcal cellulitis or erysipelas, to well-localized abscess formation such as the staphylococcal furuncle, or to chronic granulomas, such as the tubercle or gumma.

Generalized disease may occur in two forms as *bacteræmia* or *toxæmia*

Much confusion is caused by the indiscriminate use of the terms, bacteræmia septicæmia and pyæmia. We regard *bacteræmia* as a non-clinical term indicating only the presence of bacteria in the blood stream *septicæmia* as a clinical syndrome associated with a bacteræmic infection and we use the term *pyæmia* to denote a type of bacteræmia in which metastatic abscesses occur It is probable that in health small numbers of bacteria from time to time enter the blood stream, but they are immediately removed by cells of the reticulo-endothelial system. Transient bacteræmia is liable to occur after any manipulation of infected tissues and in certain circumstances, may initiate serious infections. Thus portal pyæmia occasionally follows catheterization of an infected bladder and subacute bacterial endocarditis the extraction of a septic tooth Examples of bacteræmic disease are enteric and undulant fevers and streptococcal septicæmia Pyæmia most frequently occurs in severe staphylococcal infections.

The generalized diseases associated with exotoxin producing organisms are very different in these, though the manifestations of the disease are widespread, *the infection is essentially a local one*. In scarlet fever for instance, blood cultures are typically negative the generalized rash is entirely due to the absorption of toxin from the local tonsillar infection Similarly the severe damage to cells of the central nervous system in tetanus and diphtheria is caused by toxin formed by bacteria which are themselves confined to the local lesion.

In the earlier sections we have stressed how different species of bacteria differ from one another in their capacity to produce disease, in the armament they possess and the type of disease with which they are associated. It must also be appreciated that there may be considerable variations in virulence amongst individual members of the same bacterial species. The virulence of a strain may often be *enhanced* by repeated animal passage loss of virulence (*attenuation*) can frequently be induced by prolonged growth on artificial media. It is possible that in nature these processes of enhancement and attenuation are continually occurring.

Resistance to Infection. This varies greatly with the individual. Resistance or immunity may be of two kinds, *general* and *specific* It is well known that the person who has recovered from one of the infectious fevers, such as chickenpox or mumps, is unlikely to suffer from further attacks of that disease he has acquired a *specific immunity* but his resistance to other infections (*general immunity*) is unaltered or may actually have decreased if his illness has been a severe one.

The factors concerned with the maintenance of *general immunity* are numerous and on the whole obvious a well-regulated diet and adequate amount of rest are two of the most important. Exposure to cold, and exhaustion whether from extreme physical exertion or prolonged illness, on the other hand increase susceptibility to infectious disease, and it is for reasons such as these that special precautions have to be taken to guard the premature infant and debilitated child against contact with infection.

The importance of intact epithelial surfaces as barriers against infection deserves special mention in a surgical text book any break in their continuity from the smallest surgical incision or burn to the extensive areas of the parturient uterus, decreases resistance to bacterial invasion. Though local pyogenic infections are the most common it is probable that the micro-organisms causing many other diseases often gain entrance in this way (*e g* the virus of anterior poliomyelitis after tonsillectomy)

Specific Immunity It is convenient to subdivide specific immunity into two main classes, *innate* immunity and *acquired* The latter may be

(1) Active (*a*) naturally acquired (*b*) artificially induced.

(2) Passive (*a*) naturally acquired (congenital) (*b*) artificially induced.

Innate Immunity Different animal species display wide differences in their resistance to various bacterial parasites or their toxins. The difference between the susceptibility of the rabbit to inoculation with bovine and human tubercle bacilli, it will be remembered, is so great that the rabbit is frequently used for distinguishing between these two varieties of *Mycobacterium tuberculosis* The hen, to cite another well-known instance can withstand many thousand times the dose (per Kg. body weight) of tetanus toxin that will kill a horse. Among mankind there are well-marked racial differences in the incidence and severity of different diseases, but it is often impossible to determine

how far these are due to genetic differences in resistance and how much depends upon differing risks of infection or other environmental factors. Careful surveys, however, have been made of the incidence of tuberculosis among white and coloured populations living under similar conditions in various cities in the United States, and the findings of these, that both incidence and mortality are higher amongst coloured people, is generally accepted as evidence of differing *racial immunity* to tuberculosis.

Active Immunity. After an attack of a certain disease an individual may become resistant to further attacks; this is the simplest type of naturally acquired immunity. The exanthemata are good illustrations of this point, for the immunity they confer is, as a rule, good and may be lifelong. In other infections, however, such as those due to staphylococci, streptococci or the viruses of herpes simplex and the common cold, immunity may be very transient. There is evidence that many people acquire a natural immunity without ever suffering from a clinical attack of the disease in question; their resistance probably results from subclinical or latent infections.

Active immunity may be *artificially induced* by the inoculation of:

(a) attenuated living micro-organisms, e.g. the Calmette-Guérin strain of tubercle bacillus (B.C.G.), yellow fever and smallpox vaccines;
(b) killed micro-organisms, e.g. typhoid-paratyphoid (T.A.B.), typhus, cholera and plague vaccines;
(c) toxoids (exotoxins which have been detoxified by treatment with formalin), e.g. diphtheria, tetanus and staphylococcus toxoids.

Passive Immunity. The blood serum of an immune individual frequently has protective properties which can be transferred to others. It is possible, for example, to protect a child susceptible to measles by giving, parenterally, serum from a person convalescent from that disease. The substances responsible for these specific properties of immune sera are called *antibodies*; because they are invariably found in the gamma globulin fraction of the serum and cannot be separated from globulin, antibodies are now generally considered to be specially modified serum globulins, and they are in all probability largely produced in lymphoid tissue by cells of the plasma cell series.

In active immunization the animal is stimulated to produce its own immunity; *passive immunity*, on the other hand, is conferred by the transference of ready made antibodies from the immune to the non-immune animal. In man passive immunization occurs *naturally* in the transmission of maternal antibodies to the infant *via* the placenta and, to a very much lesser extent, *via* the colostrum. It may be *artificially induced* by the parenteral administration of human serum or whole blood (e.g. convalescent measles serum) or more often of the serum of animals, usually horses, which have undergone an intensive course of active immunization (so-called hyperimmunization). These antisera may be *antibacterial*, e.g. pneumococcus and anthrax antisera, or *antitoxic*, e.g. diphtheria, tetanus, staphylococcal and gas gangrene antitoxins.

Practical Points Concerning Artificial Immunization. Active and passive immunization differ greatly as to:

(1) *Speed of the Immune Response.* When antiserum is given parenterally, antibodies reach the circulation immediately or within some hours, according to the route used; but in active immunization, which relies for

its effect on the formation of antibodies in the tissues of the individual immunized circulating antibodies are not present in any quantity until four to six weeks after the first injection of antigen the response to a second or "booster dose of antigen given three weeks or more after the first is very much quicker but even then takes two or three days to mature.

(2) *Duration of Immunity* Passive immunity is of short duration foreign antibodies are quickly destroyed and disappear from the circulation in a few weeks Active immunity on the other hand, may last for several years

In the prophylaxis of disease therefore, antiserum is given where an immediate protection is needed to cover a short-term risk of infection, such as the development of tetanus or gas gangrene in those already wounded. In cases where the liability to infection is ever present or recurrent over a considerable period of months to years, such as the risk of tetanus to a soldier on active service, or that of diphtheria to a school child, passive immunization is impracticable immunization must be active

In the treatment of established disease on the other hand, an immediate increase in specific immunity is needed passive immunization is, therefore, frequently used therapeutically in infections against which effective antisera are available (*e g* tetanus, diphtheria gas gangrene)

Serum Reactions. In much the same way that certain experimental animals can be sensitized to foreign proteins so that a later intravenous injection of the same antigen results in death from *anaphylactic shock* man may become allergic to the injection of foreign serum The serum reactions of man may resemble anaphylactic shock in animals *acute* anaphylactic shock is fortunately rare but may result in death within a few minutes of an injection of serum. The more common form is *serum sickness which may occur within two hours and up to twenty four days of the injection,* but which is most common between the eighth and twelfth days. Serum sickness is variable in duration protean in its symptoms—urticarial rashes, fever joint pains and œdema are the commonest—and seldom serious, though it may be associated with severe discomfort.

These allergic reactions must be distinguished from the more common thermal and cardiovascular disturbances which follow injections of serum. *The risk of allergic manifestations is negligible when human sera are used* but the added danger of *homologous serum jaundice* is introduced

The incidence and severity of serum reactions can be diminished in three ways

(1) *By careful history taking* The acute anaphylactic reaction rarely if ever occurs after the *first* injection of serum, except in those specially susceptible to allergic disorders but the risk of this accident as well as that of *serum sickness is much greater whenever foreign serum has been given* on an earlier occasion. Serum sickness, however may follow primary as well as subsequent injections. The risk of all types of serum reaction is especially high in asthmatics and others prone to allergic diseases. Before giving serum therefore it is important to know not only whether serum has been administered previously and, if so whether any reactions occurred but also whether there is any history of allergic manifestations, especially of asthma or of infantile eczema.

(2) *By giving a small test dose of serum if the history hints of special liability to serum reactions* The modern practice is to give a *subcutaneous*

dose of 0 2 ml of serum diluted 1 in 10 to allergic individuals The patient is kept warm and under observation for thirty minutes. If there is no *general* reaction, a further test dose of 0 2 ml of undiluted serum is given If no reaction occurs within the next thirty minutes the full dose is given If a patient has had serum before but gives no history of allergy it is usual to give a single test dose of 0 2 ml of undiluted serum (*Note* Local reactions to a test dose are very unreliable guides to serum hypersensitivity and particularly so if the injection has been given intracutaneously)

(3) *By never giving serum without having at hand a hypodermic syringe containing adrenaline for the treatment of sudden acute manifestations*

(4) *By using "concentrated" or "refined" antisera* The greater the amount of foreign protein injected the greater the risk of serum sickness for the allergy does not result from the specific antibodies themselves but from the serum proteins that accompany them Antisera may be "concentrated" by the separation of the antibody-containing pseudo-globulin fraction from the much larger bulk of albumen and eu globulin so that less protein need be given per unit of antibody activity Of recent years an even greater degree of purification is achieved by the use of proteolytic enzymes to digest much of the unwanted protein the resulting "refined" antisera have a very high antibody content and their use is associated with a much lower incidence of serum reactions

Wound Infections

Whenever the continuity of the skin is broken bacteria are liable to gain entrance to the underlying tissues. If their numbers are small and the tissues healthy the bacteria may be destroyed without any clinical signs of inflammation and subsequent bacteriological examination will show the wound to be sterile but if the bacteria are more numerous or their virulence is high, or if the resistance of the tissue has been impaired multiplication of the invading bacteria may occur and be accompanied by the signs of acute inflammation which we associate with the term *wound sepsis* In a certain number of wounds, however the bacteria multiply and persist in significant numbers for a considerable period of time without ever giving rise to any clinical signs of inflammation these are termed *silent infections*

The finding of bacteria in a wound shortly after its infliction is not, therefore, evidence of wound infection or even necessarily indicative of subsequent sepsis it is convenient to refer to this state as one of *wound contamination*

The liability of a wound to infection, therefore, depends upon two factors the degree of bacterial contamination and the capacity of the tissues to resist bacterial invasion Many systemic diseases lower the individual s resistance to infective disease in general in diabetes and many disorders of the blood for example, all tissues are particularly prone to infection. Local resistance is diminished by any injury but particularly by those which leave behind "devitalized" tissue or foreign bodies. Thus all wounds, however trivial, are liable to infection, though in general the larger and deeper the wound and the more damaged the wounded tissues, the greater the susceptibility to sepsis. The liability of the "clean" operation wound is slight because the damage inflicted on the tissues is minimal and not only are few organisms likely to be introduced into the wound at the time of operation, but effective measures can be taken to prevent their entrance later In the accidental wound, on the other hand, whether inflicted in civil life or in war the risk

evidence of hospital infection is provided by the high incidence of penicillin resistant *Staph. aureus* in the wounds of hospital patients as compared with the relative rarity of these strains in the general population Similar studies have shown that hospital infection is not confined to *Strep pyogenes* and *Staph aureus* but that added infections with other bacteria are by no means uncommon, the most important being *Pseudomonas pyocyanea Proteus vulgaris* and other coliform bacilli

Reservoirs of Hospital Infection. There are two main reservoirs of infec tion within hospitals (*a*) the upper respiratory tract skin and intestine of both hospital personnel and patients and (*b*) the infected wounds and other discharges of patients. The throat is the natural habitat of *Strep pyogenes* this organism is found in those suffering from scarlet fever and follicular tonsillitis and in convalescent and healthy carriers approximately 5 to 10 per cent. of the population of Britain harbour this organism in their throat and about 1 per cent, in their nose There is evidence that nasal carriage, when it occurs, is the more dangerous source of infection, for the nasal carrier is more liable not only to contaminate his hands and clothing with streptococci but also to infect his bedclothes and the dust of the room in which he lives.

Approximately 50 per cent. of people carry potentially pathogenic staphylococci in the nose and 5 to 15 per cent. on the hands or in the skin of other parts of the body This skin carriage is usually quite superficial a small but important percentage of people, however are deep skin carriers the surface of their skin becomes rapidly reinfected with *Staph aureus* after washing or after any other method of skin sterilization *Proteus vulgaris* is present in the fæces of 10 to 20 per cent. of healthy people and *Pseudomonas pyocyanea* in about 1 to 2 per cent.

Infected wounds are without a doubt one of the greatest potential sources of hospital infection because the numbers of bacteria present in a wound may be immense. Moreover it must be stressed that these bacteria are not only found in the discharge from a wound and in the dressings obviously soiled with this discharge but are often also present in large numbers in apparently uncontaminated outer dressings and plaster casts, and on healthy skin some distance from the wound.

Mode of Spread. It is customary to distinguish spread of infection (*a*) by *contact* which may be direct or indirect—such as transmission by hands, instruments, lotions, flies, etc. (*b*) by *droplets* and (*c*) by the *air*

Fluid droplets of various sizes are discharged from the mouth and nose during coughing, talking and particularly during sneezing. The fate of the bacteria contained in these depends on the size of the droplet. The small particle dries up in the course of a few seconds and forms a "droplet nucleus," which is capable of remaining suspended in the air currents of a room for several hours. Whereas there is little doubt that hæmolytic streptococci are discharged in the larger droplets, it has still to be proved that droplet nuclei carry any of the bacteria commonly concerned in wound infection. The large droplet depends for its dissemina tion upon the force of the initial respiratory explosion. Its maximum hori-zontal range is said to be 2 metres, but in practice the range is probably seldom more than 1 metre. The large droplet is not, therefore, truly air borne it may reach a wound directly but more usually it falls to the ground, on to the carrier's clothing or bedding and dries, and the bacteria which it

contains become added to the bacterial flora of the dust In the same way the infective discharges that contaminate wound dressings clothes and bedding disintegrate and eventually add their quota to the infective dust

Many bacteria including *Staph aureus* and *Strep pyogenes* can survive in dust and on bedclothes for some weeks according to conditions of light and humidity Whenever dust is disturbed the bacteria with which it is contaminated are projected into the air this disturbance is greatest during bed making and sweeping and *Staph aureus* and *Strep pyogenes* have frequently been found in ward air at these times Dust particles being relatively heavy do not remain suspended for long periods the majority of dust borne bacteria disappear from the air within twenty minutes of a disturbance Though most of these particles will re-settle on the floor or beds they may alight on any exposed surface and thus are capable of contaminating wounds instrument trays, etc., that are at the time uncovered

There is an infinite variety of ways by which contact infection can occur Hands instruments dressings ointments and lotions can all act as channels Hands are particularly important since they are also reservoirs of infection the hands of the dresser either naturally infected or contaminated from his respiratory tract or from a previous dressing, may convey infection directly or may in turn contaminate instruments, dressings, etc., which are later introduced into a wound

Preventive Measures. The aseptic technique of modern surgery has been gradually and successfully evolved with the object of preventing wound infection but frequently the principles upon which this technique depends are not put into practice during dressings and surgical manipulations undertaken outside the theatre it is in these circumstances that the bulk of preventable hospital infection occurs.

There are two alternatives for safe dressing of wounds. Either the wound may be dressed in a theatre or side-room under a strict aseptic régime, or the dressing may be done in a ward where an attempt is made to create local conditions of asepsis round the exposed wound The dressing theatre is obviously the better of these alternatives but it is possible to dress wounds *in a general ward in comparative safety if precautions are taken*

Dressings should be made as infrequently as possible and wounds dressed by a " no-touch " technique (as distinct from the " dripping finger " method of manipulating wounds and dressings with scrubbed wet hands) The essentials of the " no-touch " method, which is best performed by a team of two or three persons, are that the hands never come in contact with the wound or its inner dressings the entire wound toilet (removal of stitches drains and packing irrigation, etc.) is performed with sterile forceps. The hands of the dresser need not be surgically sterile, but must be clean and dry All sterile material needed by the dresser is passed to him by an assistant whose sole duty is to look after the dressing trolley containing only sterile equipment

Droplet infection is prevented by masking the dressing team with masks amply covering both mouth and nose and containing at least one layer of impermeable material like cellophane. The risk of air borne infection is minimized by (*a*) exposure of the wound for as short a time as possible and by uncovering only one wound at a time (*b*) by the cessation of all dust raising activity half an hour before the dressing (*c*) by the treatment of floors (and possibly bedclothes) with dust-laying oils and (*d*) by the removal

of soiled outer dressings with the minimum of disturbance into deep covered discard bins.

Indications for Laboratory Investigations. Because the treatment of wound infection can seldom be delayed until the invading micro-organisms have been cultured and identified it does not mean that the results obtained in the laboratory are solely of academic interest. Nor does the bacteriologist's report serve solely to confirm the clinical diagnosis and to enable the surgeon to reassess the prognosis and treatment. There are considerable variations in the response of individual strains of many bacterial species to chemotherapeutic agents and antibiotics it is only if cultures have been made that it is possible to test specifically the sensitivity of the invading bacteria in an individual case. Further the taking of frequent cultures from wounds is one of the most important means of recognizing and checking the occurrence of cross infection amongst wounds in hospital wards or out patient departments. From the point of view of clinical research it is only when clinical observations are correlated with bacteriological findings that real advances can be made in the recognition of infective conditions and in the comparison of different methods of treatment.

Collection of Material. This should be collected with precautions against contamination it must, therefore, be taken with sterile instruments and sent to the laboratory in a previously sterilized container (but not one containing any antiseptic) The throat swab conveniently fulfils these requirements The material should ideally consist of a sample of the bacterial flora of the whole infected site when a sinus tract or deep wound is sampled with a swab, care should be taken to insert the swab into the depth of the tract. When a dry surface is being sampled, the swab should be moistened before use with a sterile fluid, such as nutrient broth or sterile water

The amount of material received by the laboratory has a direct bearing on the results of culture and whereas the extreme convenience of the swab in general outweighs the advantages gained by the examination of larger samples there are many occasions when larger specimens yield greatly superior results. This is especially the case in actinomycosis, where in order to find the typical sulphur granules and to culture the actinomyces a large amount of pus often has to be examined Similarly the likelihood of success in the detection of the tubercle bacilli is much greater if sufficient material (at least 2 ml. of pus) is available for culture and guinea pig inoculation. Though a swab taken from the depths of the wound is usually perfectly satisfactory for the detection of gas gangrene bacilli, small pieces of excised muscle give better results for the isolation of *Cl tetani* it is desirable to examine as much of the local lesion as is available

There is great variability in the length of time that bacteria will live outside the body temperature and drying particularly influence their survival. It is important, therefore, that all specimens for culture should be sent to the laboratory as soon as possible after collection.

Bacterial Examination. Three methods are employed direct microscopy culture and animal inoculation

Direct Examination of Fresh Material Smears stained by Gram's or Ziehl Neelsen's methods, are extremely useful not only because these often enable the bacteriologist to detect micro-organisms which grow poorly or not at all in artificial culture, for example Vincent's organisms or the

leprosy bacillus and allow him in certain cases to use specially selective cultural methods but also because he is often able to give an immediate preliminary report of real value to the clinician

Culture Both solid and fluid media should be inoculated solid media because from the growth on these the relative numbers of different bacterial species can be judged and fluid media because these often allow multiplication of organisms which are present in insufficient numbers to be apparent on solid media in the first instance It will be obvious that since anaerobes are commonly present in wound infections of all kinds cultures should always be made anaerobically as well as aerobically

Blood agar plates (Petri dishes containing 5 per cent horse blood in nutrient agar) are the most satisfactory solid media, two plates are inoculated, one being incubated aerobically the other in a McIntosh and Fildes jar or other suitable anaerobic apparatus.

Robertson s cooked meat broth and Brewer s thioglycollate medium are the most convenient fluid media, since the reduced O-R potential allows both aerobic and anaerobic organisms to grow well (see p 22). After one to seven days growth the fluid cultures are subcultured to solid media for isolation and identification of the bacteria present.

Inoculation of Susceptible Laboratory Animals Inoculation with discharge or tissue from a wound is a means by which some bacteria may be recognized. The use of the guinea pig in the detection of tubercle bacilli is the best known example of this method but the method may also be successfully employed for the isolation of tetanus, gas gangrene or anthrax bacilli both guinea pigs and laboratory mice are highly susceptible to these bacteria.

Pyogenic Infections

Boil or Furuncle This is a localized inflammation of a hair follicle and its associated glands The causative organism is almost invariably *Staphylococcus aureus* and boils may be produced experimentally by rubbing a culture of staphylococci into the skin. They occur most commonly in those parts normally exposed to friction, particularly where there is a flexure and excess of sweating. The condition usually proceeds to suppuration but may be abortive and is then known as a " blind " boil.

A boil commences as a small red irritable papule from which a hair may be seen to protrude this gets bigger with increasing pain and exquisite tenderness Ultimately a whitish yellow spot is seen, surrounded by a dark red indurated area, and a core or slough comes away Symptoms are greatly relieved and rapid healing occurs by granulation. The regional lymph nodes enlarge and become tender but usually a lymphangitis is not seen Metastatic infection may occur *e g* osteomyelitis, carbuncle of the kidney or perinephric abscess but this is uncommon. People with a debilitating disease have a lowered resistance to staphylococci and diabetes may sometimes present as a condition of recurrent boils or carbuncles.

Treatment Heat applied locally relieves the pain and hastens natural resolution Dry heat however in the form of short wave diathermy or failing that radiant heat, is much more efficient but where these cannot be employed, it is wise to use an antiseptic such as mercuric chloride in the foment to decrease satellite formation If a hair is seen its extraction sometimes allows the slough to come away earlier and surgical drainage is seldom necessary

Since the advent of penicillin many boils can be resolved and for ambulatory treatment 500 000 units twice daily is effective. Those patients suffering from recurrent boils, particularly in such an area as the axilla, present one of the most difficult problems in surgery and the use of penicillin has not solved it.

Any general disease should be treated and locally ultra violet light is beneficial, but the best results follow a long holiday on a liberal diet with a full complement of vitamins. An autogenous staphylococcal vaccine seems to aid in some cases

Carbuncle. This condition is an infective gangrene involving the subcutaneous tissues, usually due to the *Staphylococcus aureus* but mixed organisms may be seen. The initial lesion may be a follicle infection, but owing to poor resistance by the patient or injudicious treatment, the infection escapes into the surrounding tissues.

It starts as a hard, painful infiltration of the subcutaneous tissues, the skin over which becomes red and dusky The swelling gradually increases in size in all directions, until a diameter of many inches may be reached. As it extends peripherally the central parts, which were formerly brawny become soft and boggy and the overlying skin shows evidence of yielding to the pressure within Vesicles form on the surface and finally pustules these in turn burst and allow a tardy exit to the ashy-grey sloughs and purulent discharge accumulated below Fresh openings gradually develop leading to a sieve-like condition of the skin some of these apertures enlarge and run into one another producing a central irregular crateriform opening at the bottom of which lies necrotic tissue As the violence of the inflammation *subsides the sloughs gradually separate, leaving a clean granulating wound.* Carbuncles most frequently occur on the back, nape of the neck and shoulders and are commoner in males when they form on more vascular parts such as the face and lips, the consequences may be even more serious, since infective thrombosis of the large veins may follow and this may quickly spread up to the cavernous sinus. The soft and spongy tissue of the cheek is a very favourable place for the extension of the necrotic process, and there may be a wide area of mischief under an apparently insignificant superficial lesion

There is often considerable constitutional disturbance of an asthenic type, although the temperature is not necessarily much raised. A temporary glycosuria of toxic origin is sometimes present, and disappears as the condition improves. Occasionally pyæmia or septicæmia may supervene.

Treatment The man with a large carbuncle should be put to bed and given copious fluids. Any general disease is treated, with particular emphasis on the search for diabetes. Locally short wave diathermy is both comforting and helpful, but failing that the old fashioned magnesium sulphate and glycerin paste (50 per cent.) with kaolin poultices is useful for the patient treated at home. Penicillin in full dosage should be employed systemically and many lesions formerly taking weeks and months to heal are better in as many days. Methods such as local autohæmotherapy or excision are obsolete, but occasionally surgical intervention is called for to enlarge an opening to permit easier drainage and removal of sloughs, but the cruciate incision with stitching back of skin flaps is no longer employed.

Where penicillin has not been used there may be much slough formation and also loss of covering skin hypochlorite solution hastens the separation

of the former and then if the granulating surface is extensive early pinch grafting is advocated to accelerate healing

Erysipelas. This is a contagious infective disease of the skin caused by *Streptococcus pyogenes* and is notifiable under the Infectious Diseases Act. The organisms gain entrance to the lymphatics by way of abrasions or as the result of operative wounds or small punctures Occasionally healthy skin appears to be attacked presumably through a hair follicle Secondary factors, such as ill health under nourishment and diabetes also play a part in infection It is more commonly seen in the aged

The symptoms usually begin with headache and malaise followed in twenty four hours by a rigor well marked pyrexia and the development of the rash If a wound is present it usually presents an unhealthy appearance while the rash is of a characteristic rosy red colour disappearing on pressure and accompanied by a sensation of stiffness and burning Pain occurs only in dense tissues, such as the scalp and marked œdema in loose tissues, like the scrotum and eyelids. In a typical case the edge advances with an abrupt continuous slightly raised margin As it fades it leaves a slightly brownish pigmentation and desquamation Vesicles may form containing serum which speedily becomes turbid but suppuration is uncommon. In the *cellulo-cutaneous* variety of erysipelas there is marked infection of the subcutaneous tissues with diffuse œdema occasional suppuration and sloughing of the skin.

A microscopical section shows numerous cocci invading the lymphatics just beyond the spreading margin while in the inflamed area there is a considerable excess of leucocytes engaged in the destruction of the cocci Regional lymph nodes are enlarged and congested

In diagnosis the points to be noted are the typical rash with its sharply defined raised edge and irregular outline It has to be distinguished from the exanthemata and other varieties of erythema such as sunburn and ultra violet radiation In the absence of complications such as meningitis, pneumonia and pericarditis, the disease is not serious although the toxæmia may be marked

Treatment Penicillin rapidly produces resolution and often avoids the necessity for soothing local applications, such as lotio plumbi ichthyol or saturated solution of magnesium sulphate

Infections of the Fingers and Hand. Pyogenic infections of very great importance are those caused usually by streptococci or staphylococci, which used to be grouped together under the term *whitlow* The prompt treatment of these conditions by antibiotics and if necessary hospitalization is of prime importance Four types are described

(1) *Subcuticular Whitlow* This is a purulent blister deep to the cuticle and following the application of heat is readily treated by removing the loose cuticle. If in relation to the nail, the latter acts as a foreign body and may require removal

(2) *Pulp Space Infection* This is an infection of the cellular tissues of the finger tip It is important as it is a closed fascial space and there is little room for inflammatory swelling without cutting off the blood supply and this will involve the shaft of the distal phalanx Pain is therefore early and severe there is exquisite tenderness but finger movements are retained Early drainage to decompress the space is advisable, and lack of sleep is a good guide to the right moment for this procedure, even before fluctuation

is detected. The incision is made on one or both sides of the pulp, but should not be a complete flap nor a hockey stick. Penicillin given early may prevent the condition going on to pus formation and is certainly indicated. A whitlow when seen late, or if not resolving properly should always be

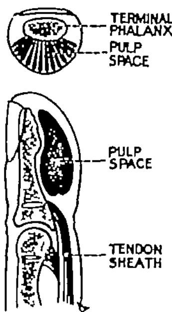


FIG 1 1 PULP SPACE INFECTION.

X rayed to exclude necrosis of the terminal phalanx and to decide when a sequestrum should be removed. Dry heat is very useful, and is best employed as short wave diathermy but X ray therapy once advocated, should not be used

(3) *Tendon Sheath Infection.* Suppuration affects the flexor tendon sheaths As is seen from the diagram the spread of infection up the arm occurs readily in the case of the thumb and fifth finger These sheaths are sometimes known as infections of radial and ulnar bursæ respectively

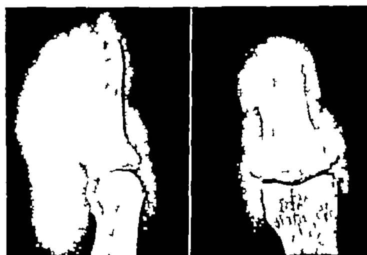


FIG 1 2. NECROSIS OF THE TERMINAL PHALANX IN PULP SPACE INFECTION.

In the case of the other three fingers spread of infection when it does occur goes to either the thenar or mid palmar fascial spaces. In this condition the finger becomes swollen with very marked tenderness over the line of the tendon sheath. It is held flexed, extension is resented and both active and passive movements are absent. The condition is a serious one, there is pain and loss of sleep, spontaneous drainage is rare and it is not unusual to see bone and joint necrosis. Once established the outlook is poor for the tendon which is avascular becomes a slough or is adherent in its sheath

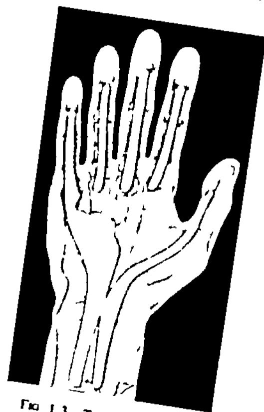


Fig 1 3 The Flexor Tendon Sheaths.

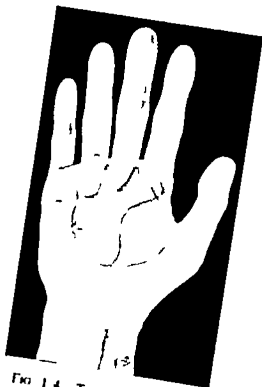


Fig 1 4 The Fascial Spaces.
M.P.S Mid-palmar space.
S.T Thenar space.

and amputation of a finger is often the ultimate result. Extension to the palmar bursæ has already been mentioned as has involvement of the fascial spaces, but either of these may lead to infection of the forearm (or Parona's) space, deep to the flexor tendons. Lymphangitis and adenitis are quite often associated with these conditions.

The condition is so disabling that early diagnosis is essential and it is recommended to give penicillin by three hourly injections, or if facilities are lacking, 500 000 units twice daily until the condition resolves. The part should also be rested in a plaster splint and the whole arm carried in a sling. By these methods it may be possible to abort the infection without drainage and of course, the results are far better. The old days of repeated soaks with sodden and macerated tissues are best forgotten. If drainage is considered necessary then this should be undertaken in a proper theatre under thiopentone anæsthesia, employing a tourniquet, so that the hand can



Fig 1 5 Incisions to drain Tendon Sheath Infections.



Fig 1 6. Incisions on the Dorsum to drain Fascial Space Infections in the Palm of the Hand.

be properly explored The incisions are indicated in Fig 1 5 but note should be taken of the following The incisions over the finger tendon sheaths should be placed laterally never anteriorly and if possible should be interrupted at the level of interphalangeal joints In the case of the ulnar bursa the sheath should be well opened but for the flexor pollicis longus sheath the incision must not be carried too high so that the motor branch of the median nerve to thenar muscles is preserved Parona s space is opened from the medial side by keeping close to the ulna and posterior to nerve and artery counter-drainage is then made from the radial side The wounds are kept open by corrugated drains or the use of strips of rubber glove Saline baths are occasionally useful but short wave diathermy is the preferable method of applying heat

At all stages of treatment particularly after drainage when pain is relieved stress must be laid upon finger exercises and the services of a physiotherapist should be employed to supervise regular active movement. Elevation of the part by suspending the limb is extremely useful diminishes pain and encourages return of function Crippling of the hand occurs so readily that everything must be done to ward off the complications of infection

(4) *Fascial Space Infection* The extent and position of the mid palmar and thenar spaces of the hand are shown in Fig 1 4 They are separated by a fibrous septum placed vertically between the palmar fascia and the shaft of the third metacarpal. Extensions named the lumbrical canals run alongside the tendons of these muscles These spaces may become directly infected following penetrating wounds, or the infection may spread from rupture and escape of pus from a tendon sheath Owing to the attachment of the palmar fascia swelling of the palm does not occur at all readily Hence although there is pain and tenderness in the palm and a feeling of tenseness, it is the dorsum of the hand which becomes swollen

The lumbrical canals are approached by incising the dorsum of the web between two fingers. Incisions for draining the two palmar spaces are shown in Fig. 1 6 It is well to remember that if possible all incisions should be kept on the dorsum of the hand Since, however the thenar space lies superficial to the transverse part of the adductor pollicis muscle it is difficult to drain unless this incision is continued a little way onto the palmar aspect of the first interspace.

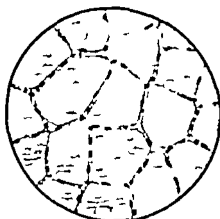
Anthrax. This disease is caused by the *Bacillus anthracis* It is primarily an infection of the large Herbivora such as cattle sheep horses and goats, Carnivora being only slightly susceptible It spreads among animals by contaminated food causing a rapidly fatal septicæmia with congestion of the intestine and lungs and splenic enlargement (*splenic fever*).

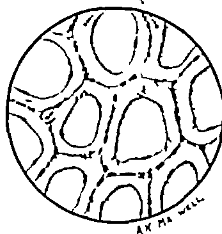
In man the disease is always secondary to anthrax in animals, and is acquired either by direct contact with an infected animal or by handling its products. Inoculation through the skin produces the malignant pustule and anthrax œdema Inhalation of the bacilli produces an inflammation of the lungs, and because of its occupational association is known as wool-sorter s disease It follows then that farmers, veterinary surgeons, slaughterers, butchers and industrial workers such as workers in hides, wool hair horn and upholstery are most liable to infection. *B anthracis* is a Gram positive, encapsulated, non motile and rod shaped bacillus It is aerobic, grows best at about blood temperature and liquefies gelatin, producing an

PLATE I









GAS GANGRENE OF MUSCLE.

The normal macroscopic and microscopic appearances are compared with those affected with gas gangrene.

TO FACE PAGE 24

the myoneural junction and the anterior horn cell with the result that muscle tone is greatly increased and the reflex response to all stimuli heightened, so that an afferent stimulus which would normally have been below threshold gives rise in the animal with tetanus to an exaggerated response.

Clinical Features Usually resulting from a contaminated wound, tetanus is characterized by a series of tonic muscular contractions, which are generally first found in the neighbourhood of the site of infection (local tetanus) but which frequently extend later to involve the entire skeletal musculature. The *incubation period* is influenced by the prophylactic administration of tetanus antitoxin in patients who have not received antitoxin, it varies from about three to twenty-one days, the commonest time of onset being the seventh day but in those receiving antitoxin the onset may be delayed enormously an incubation period of fifty days or more being not uncommon.

Tenderness and rigidity or twitching of the muscles near the local inflammatory lesion are usually the earliest signs of disease Stiffness of the jaw and later trismus, which result from involvement of the muscles of mastication, are relatively frequent findings which have given to this disease the popular name of *lockjaw* hypertonicity of the muscles of the head and neck may also later give rise to the ghastly rigid grinning expression of the face, known as *risus sardonicus* The head is usually thrown back and the body assumes a position of opisthotonus owing to the tonic rigidity of the muscles of the back the abdominal muscles are hard and board-like and the limbs stiff The characteristic " spasms of tetanus are sudden contractions of the hypertonic muscles, which may at first be only momentary and quite local usually however the entire skeletal musculature is involved and as the disease progresses the spasms become more numerous and of longer duration. They may be precipited by any form of sensory stimulus, such as bright light, the sound of a slamming door or even that of a dropping pin or by some voluntary movement. The contractions, which are generally accompanied by agonizing cramp-like pains, may be so violent that on occasion muscles may be ruptured, or bones or teeth fractured. The intellectual faculties usually remain clear throughout the disease. Death may occur from exhaustion, or occasionally from asphyxia induced by prolonged contraction of the respiratory muscles.

The prognosis varies inversely with the length of the incubation period thus, in cases of tetanus developing within one week of infection, the mortality is said to be as high as 90 per cent. within the second and third weeks it is probably less than 50 per cent. for persons who develop the disease after three weeks the prognosis is good. It is estimated that in the pre-serum days the total case mortality was about 85 per cent

Varieties of Tetanus The liability to tetanus is not confined to any particular type of wound, though like gas gangrene, tetanus most often follows accidental wounds, particularly those that are deep badly lacerated and dirt-contaminated. Not uncommonly however the wound in which tetanus toxin has been produced is small, occasionally so small as to have escaped notice healing has frequently begun before the appearance of clinical signs of tetanus. A number of varieties of tetanus are recognized *puerperal tetanus* occurs, though very rarely as the result of infection of the post partum genital tract *tetanus neonatorum* was at one time a very fatal form of the disease which resulted from infection of the umbilical cord of

infants neonatal and puerperal tetanus are not uncommon in certain parts of Africa and Asia *Post-operative tetanus* which is fortunately very rare may in some cases be the result of infections by tetanus bacilli derived from the gut *cephalic tetanus* is an extremely fatal form of tetanus which follows wounds of the head and neck and may clinically be confused with rabies owing to the predominant affection of the cranial nerves

Treatment The aims of treatment are threefold neutralization of toxin prevention of further toxin formation and alleviation of symptoms The first is attempted as soon as possible after a tentative diagnosis has been made by giving large doses (usually at least 40 000 International Units) of tetanus antitoxin intravenously and intramuscularly In addition some surgeons give a single intrathecal dose either by the lumbar route or into the cisterna magna Further daily doses should be given intravenously and intra muscularly according to the clinical response During convalescence anti toxin should be given in smaller doses at three or four days interval until the danger of relapse is past

Attention must be given to the site of infection complete excision of the wound if practicable has much to recommend it Some surgeons inject antitoxin subcutaneously around the wound

It must be stressed that antitoxin is unlikely to have any effect on toxin that is already "fixed" to nerve cells it can only prevent further toxin reaching and damaging these cells therefore in a severe case of tetanus the spasms cannot be expected to abate immediately and the maintenance of the patient s strength is a matter of utmost importance The patient should be nursed in a quiet and darkened room in order to avoid all unnecessary stimuli large doses of barbiturates or paraldehyde will usually control the spasms recently however muscle relaxing agents such as curare or mephenesin, have sometimes been used with success to supplement sedation

Prophylaxis The prevention of tetanus is much more easily accom plished than its cure because by the time symptoms have developed a con siderable amount of toxin has already been irreversibly "fixed" to the nerve cells. Tetanus may be prevented by checking the entrance of *Cl tetani* into the tissues by denying the organism the oxidation reduction conditions essential for multiplication and by raising the individual s resistance by artificial immunization

Though the risk of contamination of the accidental wound with *Cl tetani* cannot be avoided, since the organism and its spores are frequently present in soil, dust and horse dung, tetanus infections in hospital are preventable It should be remembered that like most bacterial spores, those of *Cl tetani* are highly resistant to antiseptics and to any form of heat less than that of the autoclave at 15 lb pressure per square inch for thirty minutes or of the hot air oven at 150° C. for one hour Tetanus has been traced on occasions to imperfectly sterilized dressings, especially cotton wool and sanitary towels, to talcum powder used for dressing the umbilical cord and to badly processed catgut.

Should *Cl tetani* gain access to a wound tetanus by no means always occurs multiplication and subsequent toxin formation depends on the presence of dead matter and other conditions in the wound which lower the O-R potential hence the importance of efficient wound *débridement* During the last war virulent tetanus bacilli were on many occasions isolated from the wounds of patients who never developed tetanus.

discharge behind a long foreskin may cause extreme ulceration and destruction of tissue Phimosis and paraphimosis may result from the œdema and in duration

A scraping is taken from under the edge of the ulcer and is examined for the Ducrey's bacillus Skin tests may be useful either by intracutaneous inoculation of infective material from the patient himself or by the injection of a killed culture of the bacillus.

Treatment The sulphonamides in doses of 4–5 g. daily for five days are effective. Penicillin may be used, but it is important to remember its syphilitic masking effect. Streptomycin is also effective and is less likely to mask syphilis. If none of these is available or the patient is sensitive the most useful remedy is a vaccine of the bacillus.

Syphilis

This is a specific disease due to the spirochæte *Treponema pallidum* which is a very delicate spiral filament having eight to twelve short regular curves, with sharp tapering ends. It spreads throughout the body and may be recovered from many different tissues. Acquired syphilis is almost always due to infection of the genital organs following sexual intercourse Cases, however also occur in which the disease is acquired otherwise *e g* by direct or indirect contact with syphilitic lesions forming extragenital chancres. Thus the lip may be affected as the result of drinking from an infected glass, or kissing. The spirochæte is a delicate organism which quickly loses its virulence outside the body probably explaining the rarity of indirect infection.

Clinical History This is conveniently divided into three stages.

(1) *The Primary Stage* This is characterized by the development of a chancre, associated with the enlargement of regional lymph nodes In the male it may be situated on any part of the genitalia, including the orifice of the urethra, but most commonly the prepuce while in the female it is commonly situated on the labia The most common form seen is the Hunterian chancre In males this begins as a red spot which fairly quickly increases in size, developing a margin slightly raised above its surroundings Underneath the chancre characteristic induration develops, whilst ulceration often occurs in the centre The duration of the primary stage depends largely upon how soon treatment is begun, healing taking place with little scar formation

The most important method of early diagnosis is the demonstration of the spirochætes by scraping of the chancre and examination under a dark ground illumination The chancre is cleaned with saline and the serum which oozes from the surface is transferred by a platinum loop to a slide for examination It is important to do this before antiseptics have been applied.

The Wassermann reaction (a complement fixation test) is also of the greatest value. It does not, however become positive until two to four weeks after the appearance of the chancre.

(2) *Secondary Syphilis* In the secondary stage the spirochætes have been diffused generally throughout the body by means of the blood, which is itself infective. A certain amount of constitutional disturbance may exist with a secondary anæmia and lymphocytosis. The chief secondary mani festation consists of a general enlargement of the lymph nodes, together

with the appearance of various types of rash Almost any form may be apparent and it is not always the same throughout in one individual Both trunk and extremities may be involved but characteristically more on the flexor surfaces than extensor

The mucous membranes may be affected in much the same way as the skin the fauces becoming red and congested Symmetrical ulceration usually follows starting near the anterior pillars and spreading to the tonsils and along the soft palate to the uvula These ulcers are shallow with sharply cut edges, and often present a characteristic greyish appearance constituting the snail track ulcer

Mucous patches and condylomata are somewhat similar lesions arising in the secondary stage upon mucous membranes and those parts of the skin which are soft and moist The mucous patches are white slightly raised



FIG. 1 7 A HARD CHANCRE IN THE SUPRAPUBIC REGION.

areas of enlarged and infiltrated papillæ occurring mainly at the corners of the mouth, which may go on to ulceration Condylomata are wart like masses resulting from a marked overgrowth of papillæ, occurring commonly about the anus and vulva. In the later stages of the secondary period iritis and bone pains may occur Periosteal nodes may also form, as well as chronic joint effusions or a bilateral painful epididymitis.

(3) *Tertiary Syphilis* The phenomena occurring in this stage may appear within six months of infection or not for twenty or thirty years. There is a localized or diffuse gummatous infiltration into almost any tissue in the body The involved area becomes infiltrated with large oval endothelioid cells and lymphocytes. Very few vessels penetrate the mass so formed which other wise resembles granulation tissue. In the absence of treatment, the centre breaks down and may discharge itself upon the surface producing a typical gummatous ulcer These may characteristically be seen on the leg just below the knee and are serpiginous in outline. They are described as being punched out and with a base resembling a wet chamois leather Considerable

destruction of tissue may occur but they heal with depressed white cicatrices, which are supple and smooth surrounded by pigmentation. More rarely a diffuse gummatous infiltration takes place in bone and synovia.

The liver and testes are particularly prone to tertiary infection

Late tertiary manifestations also occur but are mainly medical in character being confined to the cardiovascular and central nervous systems.

Treatment and Prognosis The modern treatment of syphilis is based on the use of penicillin, the organic arsenical compounds and bismuth. The aim of treatment is not only to heal the lesions, but also to eradicate the infection. In early syphilis 600 000 units of procaine penicillin may be injected once daily for fourteen days At the same time, injections of neoarsphenamine are given, starting with 0 3 g. then 0·45 g., and working up to 0·6 g. over a period of weeks, with a total of 5 25 g. The Wassermann reaction is repeatedly investigated at intervals for a test of cure and the C.S F after one year The patient may be considered cured if after three years all clinical and serological examinations are negative.



FIG. 1 8 ULCERATING GUMMATA OVER THE PATELLAR LIGAMENT

Treatment of Late Syphilis In late syphilis the treatment will be as for early syphilis, but preceded by potassium iodide, gr 30 (2 g.) daily and bismuth injections weekly for a month, the treatment being repeated if necessary When tertiary lesions are present in young patients, similar treatment is given, but resolution in elderly patients is obtained with potassium iodide, penicillin and bismuth arsenicals are not required.

Inherited Syphilis. Where the mother is syphilitic, pregnancy does not usually continue to term, but ends in a miscarriage after six to seven months In these cases the child may be well formed, but frequently it is stillborn and macerated with tissues teeming with spirochætes Miscarriages may recur for several pregnancies and then a living child is produced. If the infection occurs before or early in pregnancy the child is born with all the signs of congenital syphilis. If the infection occurs late in pregnancy the fœtus may escape transplacental infection, but become inoculated through some small abrasion acquired during labour

Clinical Features In some cases infancy and childhood are passed in good health, but between the sixth year and puberty isolated lesions, such as interstitial keratitis, nerve deafness, periostitis or ulceration of the palate may occur

The child may be born with many of the signs of congenital syphilis of which the commonest are wasting, enlargement of the liver and spleen and a bullous eruption on the hands and soles of the feet which has been called *pemphigus neonatorum syphilitica* Osteochondritis may be present causing pseudoparalysis After a few weeks rhinitis develops producing the typical snuffles In some cases ulceration takes place with necrosis of bone giving rise to the saddle shaped depression at the base of the nose (Figs 1 9 and 1 10) After the first year in untreated cases any of the tertiary phenomena of acquired syphilis may occur but in addition to these there are certain peculiar manifestations The permanent teeth are often deformed



FIG 1 9 INHERITED SYPHILIS, SHOWING DEPRESSED BRIDGE OF THE NOSE AND FRONTAL BOSSES



FIG 1 10 A CHILD WITH INHERITED SYPHILIS, SHOWING RADIATING SCARS ROUND THE MOUTH

the central upper incisors in particular being notched in the centre and broader at the root than crown Hutchinson s teeth Interstitial keratitis may develop about the time of puberty or earlier and nerve deafness is not uncommon. These three form Hutchinson s triad.

Bone and joint affections of inherited syphilis are described in the chapter on diseases of bones and joints.

Lymphogranuloma Venereum. This venereal disease is described in the chapter on Tropical Diseases

Tuberculosis

Tuberculosis is an infective disease caused by the *Mycobacterium tuberculosis* This is of either human or bovine type The name is derived from the characteristic nodules or tubercles produced in the tissues The factors predisposing to infection include depression of the general health from any cause Frequently the disease starts in childhood, following one of the exanthemata or other childish complaint These may leave an inflamed condition of the pharynx or intestine, providing a suitable entrance for the bacillus In adults the debilitating effects of a long illness, anæmia or tiredness from overwork may predispose to infection but the greatest

factor for all ages is bad living conditions with unhygienic surroundings—hot and ill ventilated workrooms, dark, dirty and overcrowded dwelling houses, etc. The ultimate exciting cause of tuberculosis is the entrance and development within the tissues of the tubercle bacillus. This gains access to the body in any of the following ways

(1) *By Inhalation* The sputum of consumptives may contain vast numbers of tubercle bacilli, and drying does not immediately kill them living bacilli frequently occur in dust and air Tuberculosis acquired by inhalation manifests itself usually as pulmonary disease but may appear as infection of nodes in the neck or mediastinum, from which in later years it may be disseminated.



FIG. 1 11 A SMALL TUBERCLE-FOLLICLE IN SYNOVIAL MEMBRANE.
A small multinucleated giant cell, about a dozen endothelioid cells, and numerous small lymphocyte-like cells are shown. (× 300.)

(2) *By Ingestion, e g* of infected milk from cows with tuberculous disease of the udder The bacilli enter especially the tonsils or other lymphoid tissue of the pharynx and are deposited in the cervical lymph nodes. Others pass through the stomach, infecting the intestine, and end in the mesenteric lymph nodes

(3) *By Inoculation.* This is unusual and occurs chiefly in pathologists, post mortem room attendants and butchers, etc., in the form of the wart like tuberculide known as *verruca necrogenica*.

Pathological Anatomy The tissues reaction to tubercle bacilli is the miliary tubercle, a cellular mass varying in size up to 2 or 3 mm. in diameter When young and cellular tubercles are soft, translucent, and of a grey colour tending later to become caseous, yellow and opaque In the centre lies a giant cell, oval or circular in shape and containing many nuclei arranged around the periphery Around this is a zone of epithelioid cells, and around this again a zone of chronic inflammatory cells, including lymphocytes and plasma cells (Fig. 1 11)

When the bacilli are not virulent or the patient's resistance good the tubercle undergoes fibrosis When the bacilli are virulent or the patient's resistance poor caseation occurs This is a necrotic process by which the affected tissues are transformed into a uniform structureless mass staining only with acid dyes like eosin Cure may take place at this stage by a process of fibrosis of the surrounding parts so that the caseous mass becomes walled in The cheesy mass gradually becomes dried up and may become calcified It is possible that living bacilli may persist in such dried up material and under suitable conditions recrudescence may occur even after an interval of years

In most cases in which caseation is present the process continues to spread and involve not only other tubercles but also the intervening tissue In this way caseating masses of considerable size may be produced Occasionally an exudation of fluid takes place into the mass the result being a chronic tuberculous abscess, whose contents consist microscopically of a few lymphocytes, much amorphous granular material and in the active cases tubercle bacilli

The structure of the abscess wall is characteristic. The cavity is lined by grey tissue containing miliary tubercles perhaps undergoing caasetion A chronic abscess forms a soft fluctuating swelling, painless and gradually increasing in size. If superficial, the overlying skin becomes adherent and bluish red in colour until finally it breaks down and a tuberculous ulcer is formed This has an irregular ragged margin with thin undermined congested edges. The base is formed by pulpy granulation tissue containing caseous foci

If the abscess is deep it may burrow along fascial planes, becoming superficial at some distance from its source *e g* a psoas abscess due to spinal caries. If the abscess bursts on the surface and secondary pyogenic infection supervenes, a chronic sinus is formed.

A tuberculous abscess if left to itself does not always come to the surface Occasionally one meets with a mass of putty like consistence lying in front of the spine in the body of a patient who has been cured of spinal disease. Similarly one kidney may be entirely destroyed by tuberculosis and its calcified remains found at post mortem

Laboratory Diagnosis This is conducted on one or more of the following lines

(*a*) By microscopical demonstration of the tubercle bacillus which, when stained by the Ziehl Neelsen method is acid and alcohol fast appearing as slender red rods.

(*b*) By growing the bacillus on specially enriched media This takes time

(*c*) By inoculation of susceptible animals, especially the guinea pig.

(*d*) By microscopical examination of excised tissue, which should include a search for tubercle bacilli since other lesions histologically resemble tuberculosis.

(*e*) By skin tests of hypersensitivity to old tuberculin As proposed by Mantoux, it consists of the intradermal injection of varying dilutions of old tuberculin and the result is read after forty-eight hours. At the present day the jelly test is frequently used although not so reliable as the intradermal injection. It consists in the application to the skin of old tuberculin in jelly form. An erythema is looked for after three days. In most countries the percentage of positive reactions rises with age.

Treatment General treatment consists of a sanatorium *régime* with

heliotherapy and a nutritious diet. Prolonged rest is essential. The advent of three drugs has very greatly improved in general the prognosis of this disease These are streptomycin, para-aminosalicylic acid (PAS) and isonicotinic acid hydrazide (I N H) They should be given in pairs over many months, the combination being changed at intervals.

Local treatment demands absolute rest of the affected part as far as possible In the case of bones and joints, immobilization is obtained with plaster or splints In pulmonary disease, where this is impossible, partial rest is obtained by such measures as pneumothorax.

Operative treatment is required when the measures indicated above have failed to check the disease or abscesses have developed. Extirpation, if practicable, is the ideal treatment and is carried out in such situations as superficial lymph nodes and unilateral renal disease. Partial operation of incision and scraping is sometimes used in disease of bone or lymph nodes

The treatment of chronic tuberculous abscess must necessarily vary with the condition of the part. In some superficial cases connected with infected lymph nodes the whole mass may be excised. When the skin is thin and undermined and the abscess nearly pointing, incision is required with packing of the wound with iodoform gauze.

A deep abscess covered with healthy tissue is treated by aspiration the needle being introduced from the side. Thorough aseptic technique is needed to avoid secondary infection and sinus formation

Actinomycosis

Actinomycosis is the disease in man and animals caused by the ray fungus *Actinomyces* There are many species, both saphrophytic and pathogenic, the former being widely dispersed on grasses and decaying vegetable matter These are hardy organisms growing on ordinary media at normal



FIG. 1 12. ACTINOMYCOSIS, WITH SINUS FORMATION OVER THE JAW

temperatures and when exposed to the [illegible] pathogenic species is less common. It is a delicate organism gro[illegible] enriched media with a diminished oxygen supply [illegible] with the te[illegible] kept at 37° C. This type of organism is know[illegible] *[illegible]yces isra[illegible]* [illegible]ommon resident of the mouth in carious tee[illegible] garni [illegible] ough an

abrasion In the mouth this may follow the extraction of a tooth while in the abdomen it may enter by way of a peptic ulcer or a perforated appendix The "lumpy jaw" of cattle is caused by a very similar organism but it is very doubtful if the disease is ever transmitted from animals to man The condition of "wooden tongue" in cattle is due to a specific bacillus and not the actinomyces fungus as once thought

Pathology The characteristic pathological process is the development of a granulomatous mass around a colony which after a time breaks down suppurates and discharges pus containing pale yellow grey or black bodies, the so-called sulphur granules A small coccus or cocco-bacillus known as *Actinobacillus actinomycetem comitans* is frequently found in the granules A microscopical section of the lesion shows a mass of tangled Gram positive mycelium with a border of Gram negative clubs probably representing a part of the fungus altered by tissue reaction Around the mycelium there is a zone of leucocytes, then one of histiocytes and at the periphery one containing fibroblasts and well formed fibrous tissue Spread is by direct extension Lymph nodes are very rarely involved but there is spread sometimes by the portal blood stream to the liver

Diagnosis This is made by the examination of the characteristic granules under the microscope or in their absence by microscopical section of excised tissue The clinical picture of actinomycosis varies according to the part of the body affected and the stage of the disease Three common sites are affected Cervicofacial 55 per cent. the appendicular region of the abdominal cavity 20 per cent the thorax, 20 per cent and in other parts of the body 5 per cent

The cervicofacial type may follow the extraction of a tooth and is characterized by the appearance of a smooth firm swelling usually behind the angle of the jaw which passes through a repetition of stages of breaking down, discharging and healing. Finally a pathognomonic nodular and puckered appearance is produced Pain is not usually marked and there is no involvement of lymph nodes.

The abdominal type of disease often shows itself by the persistence of a sinus following appendicectomy or in the absence of this, by the development of a fixed mass in the right iliac fossa. From here it may spread to the liver producing an irregular enlargement or into the psoas sheath sometimes eroding the vertebral bodies and entering the spinal canal

In the thoracic disease, lung or mediastinum is affected sometimes with the formation of an empyema The lower and middle lobes are most often involved and sinuses may form through the chest wall

Treatment There is no specific cure but a combination of drugs is effective Intramuscular penicillin is the most useful but large doses are required often over long periods 2 million units twice daily may be needed for periods of up to two to three months. Sulphonamides and tetracyclines may also produce benefit, while the most common drug given is potassium iodide. The dose may vary but it seems that small doses are as effective as large ones. Radiation therapy has been shown to produce marked benefit sometimes, but the dose requires careful calculation by an expert. Vaccines have been used and constitutional treatment is important to correct anaemia

Surgery is limited to the opening of abscesses or empyema, the excision of sequestra and the excision of tissue for diagnosis. Occasionally a solitary mass in the colon is excised in mistake for carcinoma

Chapter 2

CHEMOTHERAPY

Introduction

Ever since bacteria were known to be a cause of disease, attempts have been made to find antibacterial substances for treating infections in man and animals. Most of these attempts have been abortive because the majority of disinfectants are protoplasmic poisons, as liable to poison the host as the parasite Though various substances (*e g* mercury for syphilis and quinine for malaria) had for several hundred years been used specifically in the treatment of certain parasitic diseases, their use was entirely empirical Modern chemotherapy dates from 1910 when Ehrlich s systematic search for a drug which was lethal to trypanosomes in concentrations which were not toxic to man, resulted in the synthesis of arsphenamine or " 606 " and the discovery of a specific treatment for syphilis.

This and other organic arsenicals have proved extremely useful in the treatment of various spirochætal and protozoal diseases, but little progress was made in the chemotherapy of bacterial diseases until 1935 when Domagk, in the routine testing of dyes prepared by the I G Farben Industry discovered Prontosil rubrum, a red dye with which he was able to protect mice against streptococcal infections. French and English workers showed that the antibacterial activity of this compound was due not to the dye itself but to para-aminobenzene sulphonamide (sulphanilamide) which it liberated in the body the modern group of chemotherapeutic substances, the sulphonamides, are the result of the substitution of different chemical groupings about the sulphonamide nucleus.

The antibacterial action of the products of various bacteria and moulds had been recognized since the days of Pasteur but until recently none had proved to be of clinical value. In 1928 Fleming noticed that a culture plate contaminant, *Penicillium notatum* inhibited the growth of staphylococci, and from a culture of this mould he made the first crude extract of penicillin. It was, however not until after 1940 when Florey and his colleagues had worked out methods for preparing this substance in bulk in a potent and stable form that the immense therapeutic potentialities of penicillin were realized this led to intensive investigation of the antibacterial properties of different moulds and bacteria and to the isolation in 1944 of streptomycin by Waksman and in 1948 of chlortetracycline (Aureomycin) and chloramphenicol (Chloromycetin).

The synthesis of chloramphenicol on a commercial scale first showed how artificial was the subdivision of antibacterial substances into chemotherapeutic agents—synthetic drugs, and antibiotics—natural substances elaborated by plants, moulds and bacteria.

Sulphonamides

The substitution of different chemical groups in the side chains of the sulphonamide molecule results in compounds which differ very widely in toxicity solubility and antibacterial activity Whereas the efficacy of *sulphanilamide* was limited to streptococcal infections the introduction of a pyridine ring gave *sulphapyridine* a much greater therapeutic activity but at the expense of increased toxicity Both compounds have been largely superseded by drugs of similar or somewhat greater antibacterial activity than sulphapyridine but of lower toxicity They differ from one another mostly with regard to their properties of absorption and excretion

When sulphonamides are taken by mouth, absorption into the blood stream takes place from the small intestine they are excreted in large amounts in the urine unchanged or " conjugated " to other groups (mainly acetyl) they are present in the saliva sweat and breast milk in concentrations similar to those in the blood The " conjugated " compounds which are formed principally in the liver are inactive therapeutically but they are of considerable practical importance in that many of them are less soluble than the original sulphonamide and tend to crystallize out during excretion through the kidney and block the urinary passages For this reason when giving sulphonamides it is advisable to maintain a daily urinary output of at least 1,500 ml and since the solubility is greater in an alkaline urine to administer alkalis (such as mixture of sodium citrate ½ fl. oz. or 15 ml. with each dose of sulphonamide) If a mixture of sulphonamides (*e g* sulphathiazole, sulphadiazine and sulphamerazine) is given instead of a single compound the risk of crystallization is much reduced, for the presence of one compound in the urine does not affect the solubility of the others.

Pharmacology No detailed pharmacology is attempted here but some of the more important differences in the properties of commonly used sulphonamides are given below

Sulphathiazole This has a greater bacterial action and is very much less toxic than sulphapyridine It is both absorbed and excreted rapidly and must be administered at four-hourly intervals to maintain a high blood concentration its concentration in the cerebrospinal fluid is poor

Sulphadiazine This is less rapidly absorbed and more slowly excreted than sulphathiazole, with the result that, although it takes longer to produce a bacteriostatic concentration in the blood, a high level once it is produced is more easily maintained A good concentration is produced in the cerebrospinal fluid Toxic reactions are less frequent with sulphadiazine than sulphathiazole Its antibacterial activity which is very similar to that of sulphathiazole, is on theoretical grounds unlikely to be surpassed by any newer sulphonamide

Sulphadimidine This drug combines the advantages of sulphathiazole with those of sulphadiazine in that it is rapidly absorbed and less rapidly excreted six to eight hourly medication is possible.

Sulphamerazine Another homologue of sulphadiazine, this is rapidly absorbed and excreted even more slowly than sulphadimidine dose for dose it gives a higher and more persistent blood level than any other sulphonamide, except the recently introduced sulphamethoxypyridazine (Midicel Lederkyn) Sulphamerazine is not a safe drug to give to children since it is liable to produce crystal anuria

Sulphadimidine, its isomer *sulphasomidine* (Elkosin) *sulphafurazole* (Sulfisoxazole, Gantrisin) and *sulphamethoxypyridazine* are all much more soluble than sulphadiazine or sulphamerazine in urine and are almost entirely free from this risk of crystallization in the urinary tract therapeutically they are some of the most active and least toxic sulphonamides. *Sulphamethizole* (Urolucosil) is a highly soluble sulphonamide sometimes used for long continued prophylaxis of urinary infection in doses of 0 1 to 0 2 g. 5 times a day This is said to maintain a bacteriostatic concentration in the urine.

The parenteral administration of sulphonamides is difficult because of the alkalinity of most of the soluble sodium salts and the consequent risk of tissue necrosis or venous thrombosis at the site of injection *Sulphacetamide* the sodium salt of which is neutral, does not give rise to these difficulties this drug may safely be introduced into the eye or paranasal sinuses

Sulphaguanidine Succinylsulphathiazole and Phthalylsulphathiazole These form a group of sulphonamides which, being incompletely absorbed, are used for their local bacteriostatic effect in the intestine Whereas 30–60 per cent. of an oral dose of sulphaguanidine is absorbed only about 5 per cent. of the two sulphathiazole derivatives is absorbed absorption is, however increased by ulceration of the bowel. Sulphaguanidine not only has a lower therapeutic activity but is also more liable to give toxic reactions than the other two compounds, whose toxicity is extremely low

Mode of Action. The action of sulphonamides is bacteriostatic not bactericidal. It is believed that by blocking the bacterial absorption of para aminobenzoic acid (PABA) an essential growth substance, they prevent the multiplication of susceptible micro-organisms without destroying them Their destruction must be completed by the defence mechanisms of the body If the bacteriostatic concentration of sulphonamide falls before this happens bacterial growth will recur and the infection re-establish itself For this reason it is necessary to maintain a bacteriostatic concentration in the tissues throughout treatment by the administration of the drug at regular intervals throughout the day and night.

Besides para-aminobenzoic acid itself other compounds containing the PABA group can antagonize sulphonamide action some of the most important of these are local analgesics such as procaine

Indications for Use. Penicillin and the newer antibiotics have almost entirely replaced the sulphonamides for the treatment of streptococcal, pneumococcal and gonococcal infections, for which they were previously the drugs of choice

At the present time the main indications for sulphonamide therapy are (*a*) meningococcal infections because of the very great susceptibility of this organism to sulphonamides which reach the cerebrospinal fluid in much higher concentration than any of the antibiotics (*b*) urinary infections with coliform bacilli (*c*) pre-operative preparation of the bowel for surgical operations. For this, the poorly absorbed succinyl and phthalyl sulphathiazoles are frequently used and (*d*) certain skin infections, such as erythema multiforme.

Methods of Administration. *Systemic* The scheme of dosage for adults which used to be recommended as suitable for sulphanilamide, sulphapyridine sulphathiazole and sulphadiazine, is as follows An initial 2 g orally followed by 1 g. four hourly for two days, 1 g. six-hourly for two days and 1 g. eight hourly for two days.

With the present large choice of less toxic compounds such as sulphadimidine there is little justification for the use of these earlier sulphonamides or because of the risk of crystalluria for the use of sulphamerazine

The usual dosage of sulphadimidine and allied sulphonamides is 2–4 g. initially followed by 1 g eight hourly the dosage recommended for sulphamethoxypyridazine is 1–2 g initially followed by 0·5–1 g daily Children are given proportionately smaller doses

Local Action in Intestine The dosage for sulphaguanidine is 6 g. initially followed by 3 g. six hourly for four days or longer and 3 g eight hourly for four days Succinylsulphathiazole and phthalylsulphathiazole are given in smaller doses a total of 12–18 g per diem and 3–12 g. per diem respectively being given in divided doses.

Local Application Sulphonamides may be applied locally to wounds burns etc., as a powder or incorporated in a cream but are now seldom used The repeated application of sulphonamides to skin lesions is strongly contraindicated by the high risk of skin sensitization Both powder and cream must be sterilized before use

Toxicity The most common toxic effects are nausea and vomiting. Hypersensitivity in the forms of skin rashes and drug fever though less common is a strong indication for stopping treatment as are neutropenia agranulocytosis, and oliguria In any of these events the fluid intake should be increased in oliguria it may be necessary to flush out the renal pelvis by ureteric catheterization.

The risk of toxic effects are diminished if the following precautions are observed (*a*) Whenever possible a history should be taken before beginning sulphonamide treatment to find out whether the patient has been given these drugs before and if so whether he experienced any ill-effects. (*b*) An adequate output of alkaline urine should be maintained (*c*) The total dosage of sulphonamides, midnight to midnight, should be recorded on the patient s temperature chart in grammes (not tablets) (*d*) A total and differential leucocyte count should be undertaken twice a week when sulphonamide treatment is continued more then seven days

Synthetic Antituberculous Drugs

The sulphones, derivatives of diamino-diphenyl-sulphone, are of historic interest in that they were the first drugs shown to have a therapeutic effect on experimental tuberculous infection. Toxicity prevented their use in human tuberculosis but they have proved valuable in the treatment of leprosy

Para-aminosalicylic Acid (*PAS*) This does not compare with streptomycin or isoniazid in antibacterial effect but it can be administered for long periods with less risk of serious toxic manifestations than is the case with streptomycin. Its role is that of an adjuvant to streptomycin or isoniazid therapy in tuberculosis

Isoniazid (*Isonicotinic Acid Hydrazide*) This is relatively non toxic and has the most powerful action on the tubercle bacillus, both *in vitro* and *in vivo* of any drug yet known but its therapeutic effect is short lived because of the rapid development of drug resistant organisms. This resistance is very greatly delayed if streptomycin and/or PAS is given at the same time. In the modern chemotherapy of tuberculosis a single drug is never used.

Antibiotics

Penicillin. This name is given to the sodium and calcium salts of the antimicrobial organic acids that are produced by the mould *Penicillium notatum*. Several penicillins of differing chemical composition are recognized of these benzylpenicillin (penicillin G) is the most important medically and it is in this form that by far the greatest proportion of penicillin in the crude extract is found.

"Crystalline" penicillin is pure benzylpenicillin, a white powder less pure preparations are yellow or brown. Dosage was measured originally in terms of the "Oxford unit, a purely arbitrary one which corresponded roughly to the amount of penicillin, which, when dissolved in 50 ml. of broth, would inhibit growth of a certain staphylococcus This unit has been adopted as an international one and is defined as being the equivalent of 0·0006 mg. of the International Standard of pure penicillin G

Solutions of penicillin are unstable and deteriorate quite rapidly at *ordinary temperatures in a dry state, however penicillin keeps its activity* for long periods if stored below 15 C. It is distributed sterile in sealed bottles and should be dissolved immediately before use in sterile distilled water or saline.

Mode of Action. Penicillin is inactivated rapidly by changes in pH or through contact with heavy metals, thus there are few antiseptics with which it can be used Similarly a considerable proportion of a dose of benzylpenicillin given by mouth is inactivated in the acid conditions of the stomach and the amount absorbed varies so greatly that, except in infants, the oral route is unsafe for the treatment of serious infections. The recently introduced phenoxymethyl salt, known as penicillin V is free from this disadvantage being acid stable a considerably higher proportion of the oral dose is absorbed.

For a systemic effect, therefore, penicillin is usually given parenterally it is absorbed rapidly into the circulation after intramuscular or subcutaneous injection but is also rapidly excreted by the kidneys. Since the speed of excretion depends on the blood concentration, it follows that the duration of effect is by no means directly proportional to the dose doubling the dose only prolongs the effect about one-third. After a dose of 25,000 units, penicillin is detectable in the blood for about 2¼ hours and after 50,000 for 3 hours after 250,000 units for 5 hours and 500,000 units for 7 hours

Penicillin differs from the sulphonamides in having a bactericidal as well as a bacteriostatic action. There is a wide variation in the susceptibilities of different species of bacteria to penicillin in general, the cocci, Gram positive rods and spirochætes are susceptible to its action, the Gram negative rods resistant. It must be appreciated, however that the term "sensitivity to penicillin" has no absolute value and though the organisms we term "sensitive" are inhibited by concentrations considerably lower than those attained in the blood stream, many "resistant" bacteria are also inhibited if the concentration is sufficiently high. For example coliform organisms which are resistant to the highest concentrations usually found in blood, are frequently sensitive to the much greater concentrations present in urine This is the rationale for giving penicillin in urinary infections. Many "resistant" bacteria are, however able to multiply in very high concentrations of penicillin and many produce penicillinases, enzymes which destroy penicillin

It is for this reason that preparations containing penicillin must be dispensed and administered with strict sterile precautions

Considerable variations in susceptibility to penicillin are found within some bacterial species (e g staphylococci viridans streptococci and anaerobic actinomyces) which make it advisable to control the treatment of these

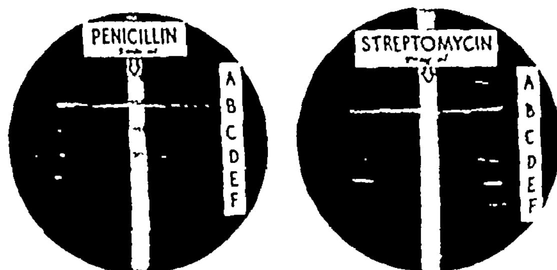


FIG 2 1 THE DITCH PLATE METHOD FOR TESTING THE SUSCEPTIBILITY OF BACTERIA TO ANTIBIOTICS

A trough is cut from a blood agar plate and filled with melted agar containing the antibiotic, which diffuses into the surrounding medium. The strains of bacteria to be tested are streaked across the plate at right angles to the ditch. Resistant organisms grow up to and across the ditch susceptible organisms are inhibited at varying distances from it.

Strain tested	*Reaction to*	
	Penicillin	*Streptomycin*
A. *Pseudomonas aeruginosa*	resistant	sensitive
B. *Escherichia coli*	resistant	resistant
C. *Escherichia coli*	resistant	sensitive
D *Staph. aureus*	resistant	sensitive
E. *Staph. aureus* (Oxford strain)	sensitive	sensitive
F *Streptococcus pyogenes*	sensitive	sensitive

infections by testing the sensitivity of individual strains. Penicillin differs from the sulphonamides in a further important respect namely that organisms do not appear readily to develop resistance during treatment, even on an inadequate dosage. However penicillin treatment does not in any way prevent secondary infection with resistant organisms and there is considerable evidence that this type of cross-infection is not at all uncommon in hospitals and surgeries.

Systemic Administration In order to maintain a constant bactericidal concentration in the tissues, many of the earlier attempts at systemic adminis-

tration used continuous intravenous and intramuscular drips (100,000 units/day) As supplies became more plentiful, these methods were abandoned for intermittent intramuscular injections at a much higher daily dosage. Opinion is at present divided as to whether it is necessary or even desirable to maintain a bacteriostatic level throughout treatment. On the grounds that micro-organisms are most susceptible to penicillin when they are growing rapidly it has been suggested that widely spaced large doses may be preferable Below is shown the interval that may be allowed between doses in the treatment of an infection by an organism of normal sensitivity

Doses of Penicillin in Aqueous Solution given Intramuscularly or Subcutaneously	*Interval*
25 000 units	3 hours
50 000 units	4 hours
100 000 units	6 hours
250 000 units	8 hours
500 000 units	12 hours

An alternative to repeated injections of aqueous solutions of crystalline penicillin is provided by various slowly absorbed penicillin salts, the three most important being procaine, benethamine and benzathine penicillins. A dose of 600 000 units of procaine penicillin will give a bacteriostatic blood concentration for 24–36 hours, the same dose of the benethamine penicillin for at least 4 days and of benzathine penicillin for some days longer the blood concentrations are correspondingly lower with the delay in absorption. Further delay may be achieved by the use of oily suspensions There is a large range of proprietary preparations which combine one or more of these poorly soluble salts with crystalline penicillin so as to achieve both long action and an initially high blood concentration. For example, 300 000 units of procaine with 300 000 units of crystalline penicillin is suitable for daily injections and similar quantities of procaine and crystalline penicillin with 500 000 units of the benethamine or benzathine salt as a "single shot treatment

Oral Administration If penicillin is to be given by mouth the dose must be very considerably higher than would be given by injection. Laboratory experience has shown that satisfactory blood levels can be achieved when penicillin V is given 4-hourly in doses, for an adult, of 120 mg. Very much higher blood concentrations may be maintained if the urinary excretion of penicillin is diminished by probenecid, but because of risks of toxicity this is not recommended except in special clinical circumstances, where constant supervision is possible.

It must be emphasized that frequent intramuscular injections of crystalline penicillin give rise to higher and more certain blood concentrations than any other means of administration and is the method of choice in life-endangering infections

Local Administration Penicillin may be used locally as a dry powder diluted with lactose or sulphonamide (500 units per g.) or as a cream (500–1 000 units per oz. 30 ml) Empyemata, brain abscesses and similar localized purulent conditions may be treated by aspiration and replacement with penicillin solutions of from 500 to 100 000 units per ml.

Penicillin does not normally pass into the cerebrospinal fluid, solutions

containing 1 000 units per ml may be given intrathecally in meningitis the pure sodium salt however must be used Penicillin has been incorporated into dental cones, pastilles and chewing gum for the local treatment of oral infections Whatever the form of local application in all severe infections penicillin should in addition always be administered systemically

Toxic Effects Penicillin differs from all known chemotherapeutic agents in that high concentrations are without toxic effect on tissue cells The most common side effects of penicillin therapy are local reactions These are of several kinds.

Immediate and transitory discomfort may be felt and is due to hypertonicity of the injected fluid when a large dose of penicillin is given in a small volume of diluent

Pain induration and sometimes a "sterile abscess" may form due to the foreign body reaction which may follow long-acting preparations especially those containing benzathine and benethamine penicillin. This was particularly common with, and led to the disuse of beeswax as a suspending medium for penicillin

Pain, erythema and induration may also be due to allergic reactions The onset may be very rapid in the patient already hypersensitive to penicillin or may not develop until after the tenth day in a manner analogous to serum sickness Delayed reactions are most frequently found after long acting penicillins.

Another type of local reaction is found in the sore mouth and black tongue which are infrequent accompaniments of oral treatment. They are due to alteration in the normal flora and the overgrowth of penicillin resistant strains of bacteria

More serious than local complications are the generalized manifestations of penicillin hypersensitivity These are severe and sometimes intractable dermatitis and the very rare but occasionally fatal anaphylactic phenomena. The question of the incidence of penicillin hypersensitivity is much debated. The incidence appears to vary considerably in different parts of the world and certainly appears to be higher in the U.S.A. than in Great Britain where allergic reactions are relatively uncommon. Serious anaphylactic reactions are most common in asthmatics and persons with other manifestations of allergy and in those who have previously had milder penicillin reactions They almost certainly never occur in patients who have never received penicillin before. It is of the utmost importance therefore before prescribing penicillin to enquire about the patient s previous experience with this drug and to pay attention to a history of previous reactions.

Streptomycin. First extracted in 1944 from the fungus *Streptomyces griseus* by Waksman streptomycin is chiefly notable for its action upon the tubercle bacillus and upon many of the Gram negative rods. It is not absorbed in any quantity from the intestine and must, therefore, be given parenterally except where a local action on the bowel is intended Like penicillin, it is dispensed as a stable dry powder which is readily soluble in water Since 1 g. of pure crystalline streptomycin has an activity equal to a million units," dosage is usually expressed in terms of weight of pure streptomycin. The salts most commonly used are streptomycin sulphate and streptomycin calcium chloride Dihydrostreptomycin which is produced by catalytic hydrogenation of streptomycin has the same antibacterial action as streptomycin

Indications Most of the common pathogens of surgical practice are sensitive to the action of streptomycin, but the degree of sensitivity varies greatly Moreover in sharp contradistinction to penicillin, a sensitive organism may rapidly acquire resistance during streptomycin treatment. Because of this and its undoubted toxicity streptomycin has a limited place in chemotherapy Its greatest use is in tuberculosis because the development of drug resistance is greatly reduced when two drugs are given simultaneously daily injections, or 3 injections a week, of streptomycin are given with oral doses of isoniazid (0 1 g. twice daily) or of PAS (5 g. four times daily) There is also a place for streptomycin in the treatment of influenzal meningitis, undulant fever serious enterococcal infections, such as endocarditis, and in certain urinary infections. Bacteriological control of therapy is essential for successful treatment.

Dosage For intramuscular injection 1 g. of streptomycin sulphate is dissolved in 4–5 ml. of sterile distilled water this salt is preferred to the calcium chloride because it is less painful. In tuberculosis a dosage of 0·5–1 g a day is usual, since treatment must be continued for long periods but in acute infections with susceptible organisms 2–3 g. may be given daily for four to seven days by four or six-hourly injections. Since 50–80 per cent. of an intramuscular dose of streptomycin is excreted unchanged in the urine within twenty four hours, high urinary concentrations are achieved. (It is perhaps worth remembering that such urines may reduce Benedict's solution and mimic glycosuria.) In urinary infections the urine should be kept just on the alkaline side of neutral (pH 7 7) as small changes in the pH adversely affect the activity of the drug.

Streptomycin may be given intrathecally in meningitis in doses of 20–100 mg. dissolved in 5–10 ml. of saline or cerebrospinal fluid

Toxicity This is great by comparison with penicillin Toxic symptoms, however seldom appear before the third week of treatment, and therefore rarely occur in the treatment of acute infections though they have been known to follow a total dose as small as 12 g. Giddiness and other vestibular disturbances are the most common forms of toxicity but other eighth nerve lesions, which may lead to tinnitus and deafness, are not uncommon when streptomycin has been given intrathecally Dihydrostreptomycin was introduced because it is free from vestibular effects but it has been found to give rise to slowly developing irreversible damage of the auditory branch of the eighth nerve, which results in the more serious complication of permanent deafness. The practice of giving equal parts of streptomycin and dihydrostreptomycin is thought to reduce risks of both vestibular and auditory nerve damage. Febrile reactions, skin rashes and nausea are occasionally encountered the incidence of these and other toxic manifestations is much greater if the daily dose exceeds 1 g.

Dermatitis is not uncommon in those handling streptomycin rashes, usually of the hands, elbow flexures and face, have been described in nurses who have administered streptomycin and penicillin for long periods. Pre*cautions should therefore be taken by all who handle streptomycin against* undue contact with the drug, e.g. by wearing rubber gloves.

Cycloserine, Viomycin and Streptovaricin. These three antibiotics are also active against *Myco tuberculosis* both *in vitro* and *in vivo* but all suffer from considerable defects due to excessive toxicity Tetracyclines also inhibit the growth of tubercle bacilli and in rather large doses have been shown to

have a therapeutic effect in combination with streptomycin Indications for the use of any of these antibiotics in tuberculosis should seldom arise none in any way rivals the present combination of streptomycin, isoniazid and PAS

The Tetracyclines. *Chlortetracycline* (Aureomycin) *oxytetracycline* (Terramycin) and *tetracycline* (Achromycin) are three analogues which have great similarity first in their antibacterial activity second in their liability to give rise to resistant strains of micro-organisms which are cross-resistant to all three and third in their side effects. They were first isolated from different strains of Streptomyces but differ from one another chemically only in the presence or absence of a single chlorine or hydroxyl group They are termed broad-spectrum antibiotics because they are active not only against a wide range of Gram positive and Gram negative bacteria but also against rickettsiæ and some of the largest viruses. Although they exhibit small individual variations, in general a micro-organism sensitive to one of these drugs is sensitive to all three

They are well absorbed when given by mouth, a satisfactory blood concentration being achieved within two to four hours and maintained for six to eight hours of a dose of 250 mg. From the blood stream they diffuse into body fluids and tissues, but the amount reaching the cerebrospinal fluid is relatively small. They are excreted in high concentrations in the urine

Indications Tetracyclines are drugs of first choice in the treatment of typhus and other rickettsial diseases, of psittacosis and lymphogranuloma venereum, of brucellosis and bacillary dysentery Their chief use in surgery lies in the treatment of infections with penicillin resistant staphylococci and in the pre-operative preparation of the bowel. They are effective in many types of urinary infection and in the symptomatic treatment of amœbic dysentery

Dosage For effective treatment a daily dose of 1 g. is usually adequate up to 4 g. may be given but overdosage only increases the risk of toxic effects. Tetracycline phosphate complex or mixtures containing tetracycline with sodium metaphosphate are more thoroughly absorbed than any other preparation of this group and, dose for dose, give higher blood concentrations than any other tetracycline thus smaller doses may be given with less risk of side effects.

Side effects About one fifth of patients experience nausea, vomiting and intestinal disturbance while taking tetracyclines these symptoms are somewhat more common with oxytetracycline than chlortetracycline and are least common with tetracycline they are, however seldom sufficiently severe to stop treatment. The most serious side effects result from the wide antibacterial action of these drugs, which leads to suppression of the normal flora of the gut and mucous membranes and is commonly followed by the unhindered growth of tetracycline resistant organisms. The overgrowth of *Candida albicans* and other fungi is associated with a sore mouth and " black tongue " and with a very distressing and often intractable perineal pruritus. The most serious complication is staphylococcal enterocolitis, which may be rapidly fatal this results from the colonization of the gut by resistant staphylococci which may have been present in relatively small numbers before treatment but which are more commonly a cross-infection with a " hospital " staphylococcus. At the onset of diarrhœa in a tetracycline treated patient, the fæces should be examined if large numbers of Gram positive cocci are seen in a direct smear the drug must be stopped and immediate steps taken

cycline and oleandomycin This combination was formulated on the supposition that drug resistance would be acquired less readily but there is no evidence that this is the case The mixture is thought to be less effective therapeutically than either erythromycin or a tetracycline in the same doses

Polymyxin B. The importance of this drug produced by *Bacillus polymyxa* is its therapeutic effect against *Ps pyocyanea (aeruginosa)* most strains of which are resistant to all other antibiotics Polymyxin is also active against a wide range of other Gram negative rods It is absorbed very poorly from the intestine and for systemic effect must be given intramuscularly Earlier preparations were severely nephrotoxic, due to the presence of polymyxin D but the pure modern preparations of polymyxin B and E are both relatively free from this effect provided that the dosage is kept within reasonable limits (1 5–2 5 mg./kg./day) and that the patient has no pre-existing renal impairment Polymyxin may be given by mouth for its local effect on the bowel or topically in various types of ear infection generally in combination with other antibiotics

Novobiocin and Vancomycin. These are two antibiotics with a range of antimicrobial action similar to that of erythromycin. Neither is without toxic side-effects novobiocin which can be given by mouth, is liable to give rise to skin rashes and fever Vancomycin, which is not absorbed from the alimentary tract must be given intravenously but carries a considerable risk of thrombophlebitis. The value of both drugs rests upon the fact that there is no cross-resistance between them and tetracycline or erythromycin thus they may be used as a life-saving measure in enterocolitis and septicæmia with staphylococci resistant to all other available antibiotics. Their use should be restricted to serious infections of this type Ristocetin is a recently introduced antibiotic similar to but not cross-resistant with, Vancomycin. It also must be given intravenously

Bacitracin and Neomycin. The value of both these which are too toxic for systemic use, lies in local treatment. The two particular dangers of topical therapy development of hypersensitivity and acquisition of antibiotic resistant strains of bacteria, are largely discounted by the fact that neither will be given systemically at a later date and because no cross-resistance occurs between these drugs and tetracycline, chloramphenicol and erythromycin. They are often given in combination as their antibacterial spectra are complementary bacitracin is very active against Gram positive and neomycin against Gram negative bacteria They are used in ointments for suppurative skin conditions, and, often with polymyxin in drops, ointments or powders for many otological infections. Both drugs have a powerful effect on the intestinal flora when given by mouth and neomycin has been used successfully in the treatment of infantile gastro-enteritis. A combination of the two suppresses the growth of almost all gut micro-organisms with the exception of bacteroides and yeasts, but it is too expensive for general use. A cheaper and effective suppressive combination is neomycin 4 g. with either oxytetracycline 1 g. or succinyl- or phthalyl-sulphathiazole 6 g these doses are given daily for two days before and one day after operation.

Nystatin. This is another Streptomyces-produced antibiotic it has little action on bacteria but exerts a strong inhibitory effect on certain yeasts such as *Candida (Monilia) albicans* Nystatin is not absorbed from the alimentary tract and can only be used for its local effect. It is effective when given by mouth in moniliasis of the gut and when applied locally in vaginitis and other local yeast infections.

Treatment (1) *The Arrest of All Bleeding* Ligation of vessels may be required but firm pressure stops capillary oozing and skin suture is often helpful, particularly in a vascular region such as scalp or face

(2) *Toilet of the Part* After covering the wound with a sterile dressing the surrounding skin must be cleaned with a detergent such as cetrimide or soap and water

(3) *Suture of the Wound* The following materials may be employed stainless steel wire silk thread horsehair nylon or silk worm gut These are all non-absorbable but for buried sutures catgut should be employed Great care should be taken to avoid tension in the wound and also exact coaptation is preferable. Use should be made of skin markings, particularly

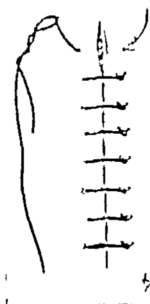


Fig. 3 1 Interrupted Sutures.



Fig. 3 2. Continuous Suture.

important at mucocutaneous junctions. Various methods of inserting sutures are employed.

(*a*) Interrupted sutures, the knot being tied well to one side.
(*b*) Continuous suture
(*c*) Blanket stitch These sutures should not be pulled too tight.
(*d*) Halsted s intradermic or subcuticular suture which leaves minimal scarring.
(*e*) Eversion or mattress suture This is useful for exact suturing of skin and to prevent inversion of the edges.
(*f*) Michel s steel clips.

(4) *Drainage* This is necessary to remove blood or exudate which provide a good nidus for organisms. Some form of rubber drain is indicated, particularly if there is a potential space. Careful bandaging reduces the incidence of hæmatoma, particularly if the crêpe variety is used.

(5) *Dressing* It is useful to apply an antiseptic as a dressing covered

Chapter 3

WOUNDS AND BURNS

WOUNDS

A wound is the solution of continuity of the skin or mucous membrane with varying extent of associated damage. In the case of a surgical incision the skin is cut with minimal underlying injury Lesions where the skin is not broken are called contusions.

Contusions. These result from external violence and consist of hemorrhage into subcutaneous tissues, and there may also be visceral injury Early on the signs are pain and swelling, while later discoloration of the part with bruising occurs. Where tissues are lax the effusion is greater but the distribution is related to the attachment of fascia and normal anatomical planes. The blood may be guided in a muscle sheath to a distant site, where the bleeding is first seen. Old people, cachectic people, and those with vitamin C deficiency tend to bleed readily following trauma, as do hemophilics. Where the collection of blood is more localized it is called a *hæmatoma*. Initially this is soft, fluctuant and tender but unlike an abscess, progresses to a harder type of lesion. If sepsis does not supervene, absorption may be complete, or calcification may occur In certain places hæmatomata may be more important and lead in the skull to subpericranial cephalhematoma or extradural hæmorrhage, or chronic subdural cyst, depending upon the original site. In minor lesions a firm bandage with plenty of wool limits extravasation, and a lead evaporating lotion is very soothing. In big localized lesions, aspiration under local analgesia through a wide bore needle is a useful procedure, but actual evacuation of blood clot is often indicated. Sepsis occasionally is seen, but fever can occur during absorption of blood clot even without the presence of organisms. Jaundice has been seen in association with very extensive hæmatomata.

Varieties of Wounds

Open Wounds. These are often classified as *incised, lacerated, contused* or *punctured* but for obvious reasons many wounds show the features of more than one type and this is particularly so in war wounds. The " through and through bullet wound forms a type of its own. A most important distinction is whether an existing wound be infected or not.

Incised Wounds. These may follow the use of a sharp instrument such as a scalpel, but may be seen following the use of a blunt instrument where the subcutaneous structures are resistant and are thus seen over the skull or any other bone. They are characterized by free hæmorrhage, retraction of the lips of the wound and lack of bruising, which is conducive to early healing with little scar formation.

The chief dangers of such wounds are hæmorrhage, involvement of nerves and tendons, risk of infection and the opening of a body cavity

Treatment (1) *The Arrest of All Bleeding* Ligation of vessels may be required, but firm pressure stops capillary oozing and skin suture is often helpful particularly in a vascular region such as scalp or face

(2) *Toilet of the Part* After covering the wound with a sterile dressing the surrounding skin must be cleaned with a detergent such as cetrimide or soap and water

(3) *Suture of the Wound* The following materials may be employed stainless steel wire silk thread horsehair nylon or silk worm gut These are all non absorbable but for buried sutures catgut should be employed Great care should be taken to avoid tension in the wound and also exact coaptation is preferable Use should be made of skin markings particularly

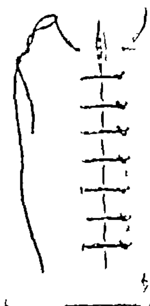


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(5) *Dressing* It is useful to apply an antiseptic as a dressing covered

by sterile gauze, chiefly to prevent the ingress of secondary i organisms.

(6) *Rest* The affected part should be rested and plaster of Pari are being increasingly used Relaxation is essential if nerves, mu tendons have been sutured

(7) *General Measures* The patient requires usual nursing care extensive and slow healing wounds may be benefited by the use of vi and iron Sutures should be removed at seven to ten days, or at a if they are constricting the wound In certain areas such as face c healing is very good owing to excellent blood supply and sutures removed from second to fifth day

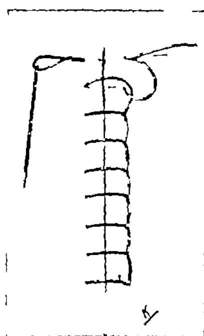


FIG. 3 3 CONTINUOUS BLANKET SUTURE.

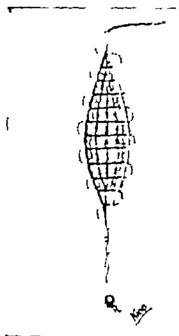


FIG 3 4 SUBCUTICULAR SUTU

Lacerated Wounds. These are characterized by tissue damag may be caused by blunt instruments, machinery road accidents and m The hæmorrhage is as a rule slight, as the bigger vessels escape inju the smaller ones curl up and retract. The local destruction of tissue with the violence of the injury but in any case there is a ready pa for organisms to flourish, particularly if there are any foreign bodies p As regards survival the immediate problem is one of shock aggrava hæmorrhage, while later the degree of infection determines the len convalescence

Treatment No hard and fast rules can be given, but only general ciples stated, depending upon the severity of the lesion. Shock ca plasma transfusion and for blood if much has been lost, while morp indicated in the presence of pain, and the dangers of over heating sho emphasized Anti tetanus serum and gas gangrene antitoxin should be prophylactically for gross lacerations, and this type of case also ca

the wound depends upon the time at which the patient reaches the surgeon's hands and also the anatomical site and the presence of vital structures such as vessels and nerves. Numerous terms have been employed—débridement, excision, revision, but probably the best term is *wound toilet*. By this is meant the cleaning of surrounding area with cetrimide or soap and water and then the excision of grossly damaged tissue from the wound itself, the exact process depending upon the conditions encountered in the particular case. The use of penicillin and sulphathiazole powder locally is also advocated initially but should not be continued. Primary suture is not usually advised in this type of wound but rather delayed primary suture or secondary suture. In any case early skin covering is advised and where loss has been extensive this may be by pinch or split skin grafts. An immediate flap is rarely used, but this is feasible when a "degloved" hand is put into a pocket under the skin of the abdominal wall.

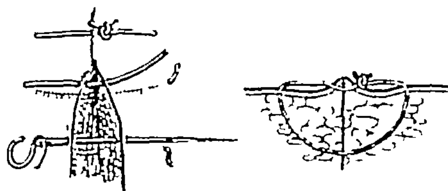


FIG. 3 5 EVERSION SUTURE

Where there has been gross trauma to big muscle groups the possibility of the *crush syndrome* arising should be considered. The exact mechanism of this is unknown, but may be associated with the release of myohæmoglobin into the circulation causing kidney damage and even uræmia. Prevention is most important and consists of giving copious fluids and alkalis. Amputation has a place in severe limb injuries, but it is always wise to have a second opinion particularly in the case of the arm. Trueta has shown how limbs can be saved by adequate immobilization in plaster after initial treatment; the use of the antibiotics together with pedicle grafting should save even more. Amputation may be called for when a limb is partially avulsed, totally crushed or in the case of severe open fractures in the aged. It may also be necessary in cases of uncontrolled gas gangrene or sepsis threatening survival or in indirect traumatic gangrene from involvement of main blood vessels.

Punctured Wounds. These are due to some penetrating instrument where deeply lying structures may be injured or body cavities opened and, of course, drainage is defective. Tetanus may follow this type of injury and should be guarded against by prophylactic serum. Most puncture wounds can be treated expectantly unless sepsis supervenes or a body cavity is involved. It is unwise to seek broken needles, unless they are readily palpable or causing symptoms. X-rays in two planes are helpful, but screening should be forbidden. The use of a tourniquet and a general anæsthetic is

recommended for exploring the hand. Electrical devices (*e.g* Berman's) are helpful for locating metallic foreign bodies.

Through and through bullet wounds can often be treated expectantly The exit wound is larger than the entry wound, which indeed is sometimes invisible The probable track of the missile must be visualized mentally to estimate what structures may have been damaged *en route* Skiagrams will exclude a retained foreign body provided it is opaque

Poisoned Wounds. Stings of bees and wasps are painful but the pain may be relieved respectively by the use of weak alkaline or acid solutions. Very rarely death has occurred immediately and this is most probably due to injection of the poison directly into a small vein. The condition may also be serious if the sting is on the tongue or at the entrance to the larynx. If œdema of the glottis occurs an immediate injection of adrenaline solution 1 in 1000 0 25 ml. should be given. If the respiratory obstruction is un relieved tracheotomy should be done. In warm climates the scorpion sting is very troublesome and exceedingly painful, but can be relieved by local injection of procaine

Snake bites are rare in this country but if encountered should be dealt with by application of a tourniquet, opening up of the wound, and the application of permanganate crystals. Most important, however is the injection of antivenene both locally and systemically

Blast Syndrome. It is convenient here to note a condition occurring in warfare in those exposed to extreme pressure waves from the explosion of bombs in air or under water Victims were found to have died of intra pulmonary capillary hæmorrhages. Those who recovered experienced great pain in the chest and expectorated blood-stained sputum.

Repair of Wounds

When any of the tissues or solid organs have been divided or injured, the reparative activities of the body assert themselves to make good the defect, unless diverted by the necessity of overcoming bacterial invasion. Even the processes involved in bacterial inflammation are useful in repair It matters little what tissue of the body is involved, the reparative process is similar in all, although modified somewhat by the local conditions. In the majority of cases the ultimate result is the production of scar tissue which serves as a bond of union between divided structures and varies in amount with the closeness of approximation, the maintenance or not of rest to the part, and the degree of inflammatory disturbance.

Actual regeneration of tissues is rarely seen, and in the case of highly specialized cells, such as the brain, does not occur Distinction is made between healing by first and second intention, but, in fact, they are merely degrees of the same process.

Healing by First Intention or Primary Union. This occurs in cleanly-cut aseptic wounds where the edges are unbruised and brought together so that no extensive collection of blood or discharge between them is possible A thin layer of blood-clot lies between the surfaces of the wound and penetrates into their irregularities, and the contraction of this clot is at first the chief means of keeping the deeper parts in apposition. There is a microscopic line of damaged tissue which, together with the blood-clot, is readily absorbed. A thin layer of granulations develops on either side and these

unite across the wound in a few days and are transformed into granulation tissue

Healing by Second Intention or Granulation. This is met with (*a*) in cases where there has been definite loss of substance and approximation is impossible (*b*) when the wound is bruised or damaged so that portions of tissue separate by sloughing or (*c*) when the advent of infection has prevented primary healing

When a small amount of aseptic dead tissue is present it is removed by an invasion of leucocytes from the surrounding vessels which disintegrate and gradually absorb it These are followed by the fibroblasts which form a layer of granulation tissue on the surface of the wound If there is much slough to be dealt with, the vitality of the granulation cannot be maintained beyond a certain distance from its source of nutrition and so by a process of simple anæmic ulceration the unabsorbed dead portion is cast off and



FIG. 3 6. WEBBING OF THE NECK FROM AN OLD BURN.

a granulating surface remains. If bacteria are present in the slough, inflammation occurs in the adjacent living tissue and this brings about a similar result, although accompanied by suppuration and fever

When, however there is a simple loss of substance with no bruising or infection, the course of events is as follows The blood-stream in the superficial capillaries having been arrested, adjacent vessels become dilated, and from these an exudation of plasma and leucocytes results. The plasma coagulates on the surface and forms a layer of fibrin, entangled in the meshes of which are a number of white corpuscles, so that the wound becomes covered with a film of whitish-yellow material known as coagulated lymph This gradually increases in amount and thickness, and is vascularized from below into granulation tissue, this process taking from four to seven days. Once the granulations have reached the surface then the epithelium grows in from the wound edge to cover it.

Healing under a scab is merely an extension of the process just described.

Scar Formation

A scar is a mass of fibrous tissue covered by epithelium which has formed during wound repair It is at first vascular and contains cells of the connective tissue type after a time as contraction continues, the cell elements become flattened out, fewer in number and less obvious. The intercellular fibrous tissue becomes more abundant, the vessels narrowed so that finally a scar becomes well nigh avascular

Where superficial it changes colour from red to white, and if small may almost disappear but never absolutely if the subcutaneous tissues were involved. When the surrounding parts become hyperæmic from any cause such as friction or infection the anæmic scar becomes evident again by contrast. Lymphatics, nerves, hairs and cutaneous glands are all absent except perhaps at the periphery and the epithelium itself is devoid of any papillæ

Pathological phenomena are as follows

Excessive Contraction. This may lead to great deformity especially when over the flexor aspect of a joint. A web-like mass of fibrous is then formed limiting movements and requiring treatment. Minor degrees can be prevented by stretching and splinting during healing.

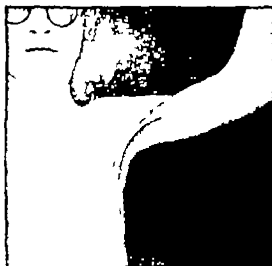


Fig. 3 7 Webbed Scar resulting from a Burn.

The chief contribution to contraction is the epithelium itself and suture *with any tension should always be avoided. Healing* without contracture can be gained by the use of split skin grafts, or the rotation of a local flap Early skin grafting in burns is most important, too in preventing deformity where the danger exists. The principles of plastic surgery must be adhered to and the defect re-established and then made good by the requisite tissue. These are described in a later chapter

Adherent Scars. These are often troublesome and painful, especially when involving bone and muscular tissues. Whenever the parts controlled by the affected muscles are moved the scar is dragged upon and pain results. Thus a scar involving the substance of the tibialis anterior and adherent



FIG. 3 8 TORTICOLLIS FROM A SCARRED STERNOMASTOID MUSCLE

to the overlying skin is dragged on in all movements of the foot and walking may become difficult or impossible on account of pain. In such cases freeing of the scar from the skin may be desirable Scars adherent to bones are difficult to deal with and may be very crippling in their results, as when the quadriceps is fixed to the lower femur

Keloid Formation. The cause is unknown but the following factors seem to operate wound sepsis, underlying tuberculous disease (*e g* following dissection of tuberculous cervical lymph nodes) a familial and racial tendency (*e g* negroes) pregnancy and also the fact that some individuals



FIG. 3 9 KELOID SCAR FOLLOWING EXCISION OF TUBERCULOUS CERVICAL LYMPH NODES.

are prone to keloid formation in any scar Excision of one keloid is often followed by recurrence but irradiation by superficial X rays or a radium plaque as soon as the stitches are removed often prevents this.

Unstable Scars. These are prone to ulceration from minor trauma due to lack of blood supply and so are seen in extensive scars adherent to a subcutaneous bony surface.

Painful Scars. These may be due to inclusion of a nerve in the scar and are seen in amputation neuromata and also where there is adherence



FIG. 3 10 MARJOLIN'S ULCER.

Malignant Disease in Scars. Where there is chronic or recurrent ulceration the epithelium may become unstable and ultimately neoplastic changes follow The best example of this is a *Marjolin's ulcer* supervening upon chronic varicose ulceration, and a similar process may follow a chronic fistula-in-ano Prolonged sepsis as in osteomyelitis or suppurating war wounds may also lead to the development of squamous cell carcinoma.

BURNS

In treating burns, it is necessary to consider whether the injury is so severe as to destroy the vitality of the part affected, or merely sufficient to induce inflammation of it. In the latter case cold applications afford great relief and if employed immediately after the accident occurs, may prevent the inflammation and vesication altogether Another mode of treatment which answers extremely well, though it is difficult to say on what principle, consists in enveloping the burnt part with cotton. The local treatment of burns has afforded a fruitful field for diversity of practice and opinion " So wrote James Syme one hundred years ago The same statements could be made to-day but with the introduction of antibiotics and increasing knowledge and control of oligæmic shock, patients with extensive burns who formerly would certainly have died now have a chance of recovery Nevertheless, from time to time patients with relatively minor burns give rise to considerable anxiety and complacency must never be permitted

Burns are wounds and as such may be closed or open. This concept must always remain the guiding factor in local care Appreciation that this form

of wounding is followed by considerable fluid loss is the guide for early fluid therapy

Classification of Burns

Burns are classified by extent and by depth Various tables have been devised to help in the estimation of the surface extent of burns the most accurate being those of Lund and Browder (1944) For emergency work a modified Berkow table is suggested and is conveniently termed "the Rule of Nine" (Fig 3 11) The head and each of the upper extremities are 9 per cent of the total body surface the front of the trunk the back of the trunk

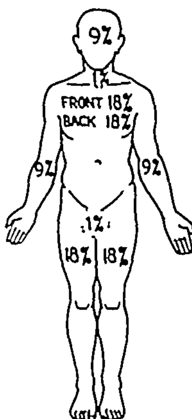


FIG 3 11 THE "RULE OF NINE," ESTIMATIONS OF SURFACE AREA, FLUID REPLACEMENT AND URINARY EXCRETION.

and each of the lower extremities are 18 per cent Such figures can be remembered readily and should prove most useful when the treatment of oligæmic shock is considered

For the classification by depth many values have been suggested. The most simple and efficient is the division into *superficial* and *deep* burns. Deep implies that at some point of the burnt area there has been whole thickness loss of skin there is no indication as to whether subcutaneous fat muscle or bone has been involved but this information is considered unnecessary in a classification. What is necessary is an appraisal of the probable destruction of skin.

Certain points are of special importance to the general practitioner A burn of slight degree is any burn which can and should be controlled by the

doctor at home it may be (*a*) a small or (*b*) a minor burn A small burn requires no further discussion A minor burn is superficial, affecting up to 5 per cent of the body surface (the anterior surface of the hand is roughly 1 per cent.) and not involving the face flexures or areas liable to contamination by natural discharges. Burns which cannot fit into this category should be referred to hospital.

With the possibility of mass casualties due to atomic warfare a new yard stick for treatment is essential. The types of burn seen would be (*a*) flash burns (mostly superficial) and (*b*) secondary burns (mostly deep) Medical personnel, if available taken forward to first aid posts, would assist to decide between minor and major burns. Minor burns would consist mainly of flash burns of face and hands, the more extensive major burns would be those resulting from ignited clothing and burning buildings. Minor burns would be treated at first-aid posts, major burns would be directed towards " cushion hospitals. The treatment of burns can best be considered under two headings, general and local

General Treatment of Burns

The first principle is to save life and there is general agreement that to accomplish this there must be early restoration of the circulating plasma volume Recent clinical observations suggest that patients with burns involving over 10 per cent. of the body surface in children and 18 per cent in adults will require intravenous therapy those with burns of less extent can obtain their fluid requirements by mouth. In mass casualties resort will have to be made to plasma substitutes. Too much stress has been placed on the assessment of oligæmic shock by repeated estimations of blood pressure and hæmoglobin or hæmatocrit values. Of much more importance are clinical assessment, the state of the peripheral circulation, the pallor the cyanosis of the lips, the degree of thirst and restlessness. Laboratory help may be non-existent, therefore clinical judgment is all important.

In superficial burns, plasma and saline are administered in equal propor tions or plasma is given alone with salt by mouth. Blood, if available, is given in all deep burns and all superficial burns of over 25 per cent. of surface area, and *should replace up to half of the plasma saline requirement in the* first eight hours. The proportional fluid requirement is

Superficial burn plasma 2 blood 0 normal saline 2.

Deep and extensive superficial burn plasma 1 blood 2 normal saline 1

The fluid loss in burns lasts for forty-eight hours after injury but is greatest during the first eight hours. In addition to the fluid given to make up for external and internal loss, sufficient is given for the daily metabolic requirement in the form of non-electrolyte fluid, *e g* glucose water

A formula has been evolved (Table A) which at first may appear to be complicated but which has in practice proved most valuable and has given confidence to both nursing and medical staffs.

It fulfils the following requirements

(*a*) The quantity of fluid given is proportional to the extent of the affected area.

(*b*) The rate of a[illegible] n is parallel to t[illegible] of local fluid loss, being highest in the [illegible]

(*c*) The amount [illegible] ional to th[illegible] blood volume of the patient.

TABLE A

Estimation of Total Fluid Requirements for First Forty-eight Hours per 1 per cent. of Area Burnt

	Age							
	0-3 mth	3-6 mth	6-9 mth	9-1 mth	1-2 yr	3 yr	3-4 yr	4-5 yr
Normal Saline (ml.)	5	7	8	9	10	14	16	18
Plasma (ml.)	5	7	8	9	10	14	16	18
Metabolic Fluid Requirement (by mouth)	160 ml per kg					100 ml per kg		

	Age							
	5-6 yr	6-7 yr	7-8 yr	8-9 yr	9-10 yr	10-11 yr	11-12 yr	Adult
Normal Saline (ml.)	21	23	27	29	31	34	37	75
Plasma (ml.)	21	23	27	29	31	34	37	75
Metabolic Fluid Requirement (by mouth)	80 ml per kg.				50 ml. per kg.			

First twenty four hours — in first eight hours post-burn; in next sixteen hours.
Second twenty four hours — total for first twenty-four hours.

Although patients with extensive burns require large amounts of fluid there is a limit to the distensibility of the interstitial space. It has been shown that fluid therapy should be restricted to a forty-eight hours total corresponding to no more than 50 per cent. increase in extravascular fluid volume, which is an amount not exceeding 10 per cent. of body weight. When the first formula is applied it is found that this limit is exceeded with any burn involving 30 per cent. or more of body area, and in such cases a second formula is used (Table B).

The importance of controlled therapy in oligæmic burn shock should be remembered and indiscriminate amounts of intravenous fluid should never be given. Tables however are guides only.

TABLE B

Fluid Replacement Formula for Burns Exceeding 30 per cent. of Body Area

Calculate 10 per cent. of Body Weight

Fluid requirement for forty-eight hours = 10 per cent. of body weight intravenously plus metabolic fluid requirement for two days by mouth.

In first twenty-four hours ½ of total { First eight hours ¼ of total. Next sixteen hours ¼ of total.

Second twenty four hours ½ of total

Although Tables A and B have proved of great value, difficulties in interpretation have been encountered by those workers who have little experience in the care of extensively burnt patients Fig. 3 12 is the result of an effort to portray the relevant information in as simple a manner as possible (Barclay 1952)

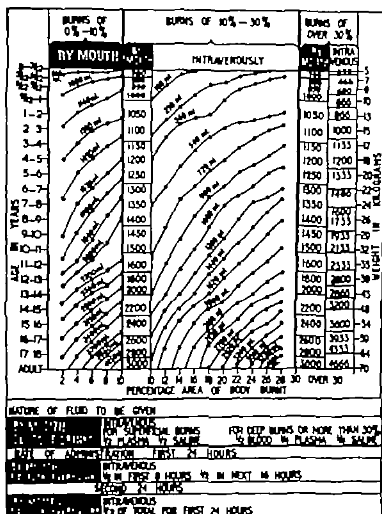


FIG. 3 12. FLUID REPLACEMENT GRAPH.

General Management of the Severe Burn. (1) *Sedation* Rest lowers the oxygen requirement of the tissues and since oligæmic shock causes death by producing tissue anoxia, adequate sedation is a logical procedure In adults, a hypodermic injection of morphine gr ¼ (15 mg.) is given in children the dose is proportional. The hospital must always be notified of the time of administration and dosage of any sedative already given

(2) *Oxygen* Administration of oxygen at the rate of 3 litres per minute by intranasal catheter has been found to be the most satisfactory method. Oxygen therapy is valueless unless nursing staff have time to control it accurately

(3) *Position.* Where possible the head-down position is adopted as in the treatment of reduced blood volume from other causes.

(4) *Heat* The application of external heat in any form is strictly avoided

(5) *Local Measures* Cleansing is omitted or postponed until the general condition is stabilized Meanwhile the burnt surface is exposed to encourage drying of the surface

(6) *Hyperpyrexia* This is an infrequent but not rare complication which occurs during the first seventy two hours after injury and unless immediate and vigorous steps are taken the patient may die Exposure, cold sponging, fans and cold packs are employed in order to reduce the temperature quickly

(7) *Antibiotics* Penicillin up to 500 000 units in twenty four hours is administered In extensive burns it is given into the drip fluid in the less extensive, intramuscularly

(8) *Hæmoglobinuria* All urine passed from the time of admission must be saved and examined A few patients with deep burns demonstrate hæmoglobinuria and in such cases unless vigorous methods are adopted anuria results. A solute diuretic, *e g* mannitol 15 per cent., must be administered

Assessment of Progress. Where possible, the following observations are recorded at half hourly or hourly intervals according to the severity of the condition.

(1) *Capillary Circulation* This is judged by the colour of the skin, *e g* pallor cyanosis, the colour return on pressure and by the skin temperature.

(2) *Mental State and Behaviour* A spasmodic restlessness occurs early in oligæmic shock and is an indication for administration of fluids. If the condition is more advanced, the patient is quiet, alert and co-operative, thirst is intense and vomiting common.

(3) *Pulse* Changes in pulse rate are of little diagnostic or prognostic significance.

(4) *Temperature* The temperature is recorded half hourly (in children, by rectum) Hyperpyrexia is treated immediately

(5) *Respiration.* The rate and character of the respirations are observed.

TABLE C

Normal Urinary Excretion

Age	*4 hours ml.*	*Per hour (approx.) ml.*
0–12 months	200–500	8–20
1–4 years	500–575	20–24
4–7 years	575–650	24–28
7–10 years	650–725	28–30
10–12 years	725–800	30–33
Adult	1,500	60

(6) *Blood Pressure* A fall in blood pressure is relatively late. A certain number of patients show a rise of pressure which may be maintained for some hours or even days.

(7) *Hæmoglobin* Especially in children, the hæmoglobin level is more variable than the hæmatocrit reading, so that the initial level may be of little significance

(8) *Urinary Excretion* This is the most valuable single guide to progress and to the efficacy of treatment (Table C) The output should always be recorded There is in burns an oliguria and the output in the first twelve hours may be very low

(9) *Fluid Intake* Oral and intravenous intakes of fluid are recorded at hourly intervals on the same chart as urinary excretion. If a patient refuses fluids by mouth feeding by gastric tube must be considered.

In some burns associated with atomic warfare there will be the possibility of radiation injury The combination of burn and radiation injury leads to much increased morbidity

Local Treatment of Burns

The guiding surgical principle is the closed wound concept. Superficial burns are " open " wounds which become closed " within 48 hours by the formation of a plasma crust Deep burns are " closed " from the first by their eschar This must be excised by the fourteenth day and replaced by skin grafts. Thus the wound is constantly closed."

The burn surface must be rendered dry as soon as possible and kept dry No local irritant substances must be applied and breaks in surface crust avoided

Two methods are possible (1) An absorptive dressing over a bland surface application and (2) exposure. The two methods are allied and can be changed over if to advantage.

The aims of any form of local treatment should be

- (*a*) to produce a condition of the burnt surface unfavourable to the growth and multiplication of bacteria by (i) the production and maintenance of a physiological dressing, the plasma crust, or an eschar if possible (ii) exposure of the surface to light if possible (iii) the reduction of the temperature of the surface to that of the environment.
- (*b*) to apply an antiseptic which is bland to tissue cells
- (*c*) to provide rest of the affected part by immobilization
- (*d*) to limit œdema by elevation
- (*e*) to render nursing care simple.

Dressing the Burn The use of " pressure dressings " has given such good results that one has hesitated to adopt any change. The pressure referred to indicates pressure on the copious overlying wool and not on the tissues. The pressure applied to the dressing and wool through the medium of the bandage gradually lessens and the dressing and wool are allowed to expand and they therefore become increasingly absorptive. A preferable term for pressure dressings would be " absorptive dressings." It is always noticeable that if the absorptive dressings are dry when they are removed at the first dressing in twelve to fourteen days, the superficial burns are healed and the deep burns can by then be safely excised and grafted.

Should dressings become and remain moist they are no longer absorptive and should be changed and further dry dressings applied

There is a popular belief that any wound covered by a dressing and bandage is "closed and that one left exposed to the air is open In doint of fact a burn left exposed is covered with a crust within forty-eight hours and that crust is more impermeable to organisms than any known dressing. The exposed burn, therefore is "open" for forty-eight hours during which time the patient receives penicillin but thereafter the surface is closed

Should any form of dressing become moist all manner of organisms can pass through from the covering bandages and what was a "closed" dressing becomes virtually completely open further the organisms have optimum



(a) (b)

FIG. 3 13 PETROL BURNS OF FACE
(a) Twenty-four hours after admission.
(b) Fourteen days later

conditions for multiplication—moisture, warmth and darkness. Before the terms open and closed are employed their full significance must be appreciated and a knowledge of the state of the burnt surface gained.

In extensive circumferential burns treated with absorptive dressings the patient must be turned four hourly to allow the moist areas to dry An Emesay turning frame is an advantage.

A good crust protects the wound, provides a scaffold for young epithelium and, in deep burns presents a barrier to the loss of protein, salt and red blood cells An intelligent nursing staff, therefore, appreciates that nothing must be permitted to occur which would disturb the formation and integrity of the crust.

Healing of Burns. This is best judged by following the cover sequence. The cover sequence in a superficial burn is crust then, within three weeks by the process of natural healing, skin in a deep burn the surgeon must

attempt to follow the cover sequence of the superficial burn The crusts are surgically removed within three weeks and the areas covered by skin grafts. *Because of the simplicity of drying by exposure the method might prove of* value in the treatment of mass casualties It is realized that there will never be one answer to the burn problem As in all surgical conditions, a surgeon



FIG 3 14. SCALD OF BUTTOCKS. FOUR DAYS AFTER ADMISSION.

must have principles of treatment based on his conception both of the *pathology or pathological physiology of the condition and of the bacterio-*logical picture. In certain definite circumstances the plan of treatment will be modified *e g* in children and old age. The treatment of the burnt child is often the treatment of the child and not of the burn a point so frequently overlooked.



FIG 3 15. SCALD OF THIGHS AND GENITALIA. *SEVEN DAYS DURATION.*

The decision as to whether the method of absorptive dressings or of drying by exposure should be adopted is made by the surgeon following discussion with the sister in-charge. Wherever nursing care is possible, the burn is exposed.

In the method of drying by exposure the burn is cleansed with 1 per cent. cetrimide, blisters are snipped and raised epidermis is removed. The burnt

surface is dried Formerly the surface was insufflated with penicillin (calcium salt of penicillin diluted with lactose 10 000 I U per g.) but this procedure is now omitted The affected part is splinted to immobilize it and if possible is elevated to limit œdema Penicillin is given systemically 500 000 units daily and a dry crust forms within on the average forty-eight hours All



FIG. 3 16 SCALD OF NECK.
Note hyperextension on pillow

sorts of organisms fall on a burnt surface but if the surface is dry no harm results.

An absorptive dressing consists in turn of well teased-out dry gauze wool and bandages. Moist dressings are not absorptive and should be changed and further dry dressings applied Sheets of gauze are useful dressings and can be cut quickly to pattern They can be sterilized in large rolls

Burnt hands treated initially by absorptive dressings do well if non

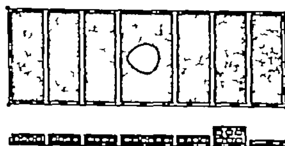


FIG. 3 17 PLAN OF SECTIONAL (DUNLOPILLO) NURSING FRAME.

adherent dressings are removed after forty-eight hours and if the burnt parts are exposed on pillows to the air

One obvious question arises, can such principles be applied for minor burns in general practice? The answer is in the affirmative. The necessary fluids can be given by mouth a dry surface is encouraged by the application

of hydrophobic tulle gras, dry dressing, wool and a firm bandage penicillin is given by injection

The method of drying by exposure should be limited to hospital practice.

Certain areas are straightforward face buttocks thighs, upper arm and forearm one aspect of trunk and genitalia. Other areas are more difficult neck hands, and circumferential trunk



FIG. 3 18 EXTENSIVE BURN OF TRUNK AND LOWER EXTREMITIES, TREATED ON A SECTIONAL FRAME.

Dermo-epidermal or deep dermal burns sometimes give concern as the crusts remain adherent up to three weeks. Liquid paraffin soaks should be applied daily from the sixteenth day

Patients admitted even seven to ten days after injury with septic burns can be treated in a similar manner The trials of the foul odour of dirty dressings and troublesome flies are eliminated.

Deep Burns. The problem of treatment of the deep burn is the surgical problem of skin replacement and is common to all methods of local treatment assuming infection is controlled. The time to intervene depends on many factors, of which the first is the consideration of the patient as a whole

rather than consideration of the injury There is no doubt that the maxim of skin coverage at the earliest possible moment is the ideal aim but except in expert hands few children and few elderly patients will tolerate extensive excision and grafting at less than two to three weeks after a severe injury Should the general condition of the patient be good the burn deep and the surgeon experienced in grafting, excision and cover can with advantage be carried out in seven to ten days from time of injury In deep burns say with both lower extremities completely involved excision and grafting might have to be done at the tenth day to allow the second leg to be treated by the twenty first day Team work is essential

A further problem is the difficulty of diagnosing the depth of the injury in the early stages if excision is carried out earlier than the eighteenth day then undoubtedly one runs the risk of excising areas where the dermis is only partially destroyed and which would have healed spontaneously had a more conservative policy been followed

The receptiveness to skin grafts of a raw surface decreases from the time of injury and in our experience it is infinitely preferable to graft as early as possible in the presence of bacteriological evidence of infection than to spend valuable weeks in trying to sterilize the surface

When grafting is judged advisable the area of crusting removed depends on the total surface area of the crust and on the skin available for cover the use of homografts must be considered There is no doubt at all that the ideal in deep burns treated by exposure is excision of the complete crust with *immediate* skin coverage, either autograft autograft and homograft or homograft To leave an area uncovered is to invite infection. Leaving out the possibility of immediate excision as already mentioned *the cover sequence in burns should be crust then skin whether the burn be superficial or deep* and there should never be a raw surface. One of the urgent necessities to-day is the training of teams to carry out extensive rapid excision and immediate skin coverage.

Following burning there is considerable metabolic upset to the patient. The daily calorie requirements are increased Frequent weighing of the patient is a useful control. In addition to extra protein to make up nitrogen loss extra fat is required.

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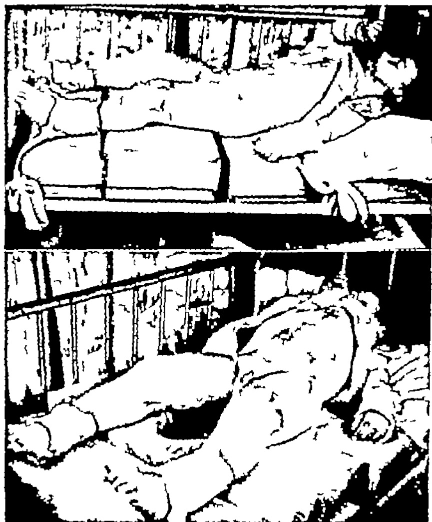


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Following burning there is considerable metabolic upset to the patient. The daily calorie requirements are increased Frequent weighing of the patient is a useful control. In addition to extra protein to make up nitrogen loss, extra fat is required.

The reason for this is that the immediate effects of severe hæmorrhage are due to the loss of blood volume, while the fall in hæmoglobin is only of secondary consideration. The life of the tissues depends primarily upon *there being an adequate circulating volume so that oxygenated blood reaches* all parts of the body The hæmoglobin level, the effectiveness of the transfer of the oxygen from the red blood cells to the tissue cells, and the efficiency of the subsequent utilization of the oxygen in the cell metabolism by the cytochrome oxidase system are of secondary importance in the consideration of the effects of a single hæmorrhage.

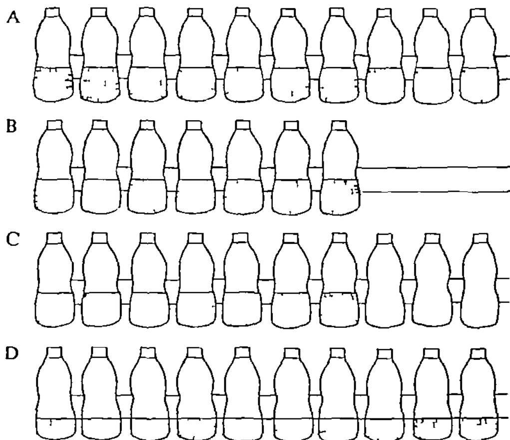


FIG. 4 1 THE RESTORATION OF THE BLOOD VOLUME AFTER HÆMORRHAGE.

A. The normal composition of the circulating blood (*i.e* 45 per cent. cells—55 per cent. plasma)
B. The blood immediately after hæmorrhage—loss of 3 " bottles."
C. The method of temporary replacement after hæmorrhage—3 " bottles " of plasma added.
D The composition of the blood after recovery from the immediate effect of hæmorrhage (*i.e* 30 per cent. cells—70 per cent. plasma).
The horizontal lines indicate the 60 per cent. and 30 per cent. levels.

To illustrate the problem simply ten M R.C. blood bottles each containing 500 ml. of blood have been taken to represent the blood volume * (Fig. 4 1) The ten bottles give a rather low average blood volume of 5 000 ml. containing, at 14 8 g. of hæmoglobin per 100 ml some 750 g. of hæmoglobin.

* The ordinary blood bottle supplied for transfusions contains only 400 ml. of blood with 120 ml. of acid-citrate dextrose solution, and for calculations 60 g. or less of hæmoglobin should be allowed per bottle of stored blood.

Allowing about 5 per cent for the plasma which remains among the packed cells in the hæmatocrit (normal for males 47 mm per cent) each bottle can be taken to contain 200 ml of cells and 300 ml of plasma and to have a hæmoglobin content of approximately 75 g

The loss of one "bottleful" (500 ml ↔ 75 g. of hæmoglobin) has little effect upon a healthy individual and blood donors can give approximately this amount (400 ml —see footnote) two or three times a year without any untoward effect Two "bottles" is definitely noticeable but can easily be replaced by a normal person although it could equally well kill an ill patient. Three "bottles" is serious and four (2,000 ml ↔ 300 g of hæmoglobin) comes into the dangerous level liable to cause death

Immediately after the loss of a substantial quantity of blood, say about three "bottles" (1,500 ml. ↔ 225 g. of hæmoglobin) the hæmoglobin level of the blood is still found to be nearly normal This may seem surprising at first sight but the hæmorrhage has created a simple reduction in the blood volume and while the total amount of hæmoglobin in the body is reduced, the amount per 100 ml of blood is unaltered During this preliminary stage the circulation is rapidly adjusted to keep up the supply to the essential organs through vasoconstriction reducing the blood flow to the less important areas The skin and the tissues of the extremities are the most obviously affected but probably the renal cortices are also cut off for this change would have a beneficial action in reducing the loss of fluid from the body

Through this vasoconstriction the blood pressure may be maintained or even elevated for a time, but usually after a short interval it falls to an extent in keeping with the degree of hæmorrhage.

If this compensatory mechanism fails the cellular metabolism of the body is grossly upset and the state of shock which develops leads to a rapid deterioration

Hæmodilution starts almost at once, in fact, it can be demonstrated during the course of the hæmorrhage, but it takes some hours for the volume to be effectively restored and the mechanism may fail altogether where there is gross dehydration. The withdrawal of fluid from the tissues is determined by the reduction of the intracapillary hydrostatic pressure which lowers the expulsive force and leaves part of the osmotic attraction of the plasma proteins unopposed. The resulting dehydration of the tissues in turn causes thirst and the ingestion of water helps to correct the fluid loss.

The new protein comes mainly from the liver and is richer in globulin than normal plasma.

When the replacement is complete and the blood volume has been restored almost to normal, the hæmoglobin and hæmatocrit readings indicate the degree of blood loss, in other words there has developed the simplest of normochromic anæmias, and in the example given the hæmoglobin will be found to have dropped to between 60 to 70 per cent. of the former value

$$\frac{750 \text{ (the total Hb)} - 225 \text{ (the Hb lost in 1,500 ml.)}}{750 \text{ (the total Hb)}} \times \frac{100}{1} = 70 \text{ per cent.}$$

At this stage of preliminary recovery the pulse becomes full and bounding with a high pulse pressure and the blood pressure has probably returned to within the normal limits. The state of the circulating blood can now be represented in the diagram by seven bottles of blood and three of plasma.

Within a few hours of the hæmorrhage there is evidence that the marrow is being stimulated to progressive activity and increasing numbers of young cells, reticulocytes, young neutrophils and platelets, are poured into the circulation during the next five or six days. Thereafter the number of young cells declines, but normal blood formation continues at a higher level until the loss is made good. During this period the presence of young cells can be detected by the slight increase in the mean diameter of the corpuscles

In between a fortnight and three weeks the corpuscle level is restored to almost normal, practically irrespective of the severity of the hæmorrhage, for the greater the loss the greater the anoxæmic stimulation to new cell production

Thus restoration of the blood volume takes only hours, and a return of the corpuscular elements to an adequate level under a month, yet complete recovery is relatively slow and is only reached when the ratio of the plasma proteins, the distribution of the cell population, and the iron stores are again normal.

The time required for the blood to return to normal and for the iron reserves to be built up again has a practical application, for it determines the interval at which blood donors can be used without causing anæmia.

Larger Hæmorrhages (2,000 to 2,500 ml. = 4 to 5 " bottles " = 300 to 375 g. of hæmoglobin) Here a different set of conditions is produced. The peripheral vasoconstriction and the immediately available reserve of tissue fluid are insufficient to keep up the essential circulation and various tissues suffer from anoxæmia. A state of surgical shock develops and the resulting upset of intracellular metabolism leads to degenerative changes in the cells, particularly fatty changes and is reflected in a rise in the blood urea

The circulatory failure added to the normal renal shunt to conserve fluid, places the kidneys in a most unfavourable position and the tubules, which are supplied by the most distal parts of the renal circulation suffer most. The epithelium of the tubules degenerates and the function of selective reabsorption of the glomerular filtrate, which is a specialized adaptation of the normal reabsorption of the lymph on the venous side of the capillary loop can no longer be carried out and all is allowed to pass back into the renal stroma and the venous side of the renal circulation.

If the reabsorption is complete the anuria which follows leads in some cases to delayed death from uræmia, but in others the outcome is more fortunate, the tubular epithelium regenerates and the secretion of urine is restored. Thus death can take place or the anuria pass off at any time up to about fifteen days after the hæmorrhage.

In addition, it would appear that from time to time certain other tissues have an increased sensitivity to the effects of hæmorrhage. Thus, for example, the pituitary gland is liable to be picked out and undergo necrosis when the normal involutionary changes at the termination of pregnancy are upset by a severe postpartum hæmorrhage, while the sudden onset of blindness following a severe hæmorrhage is well known. This selective anoxæmia is more common in conjunction with arterial degeneration and coronary atheroma underlies the precordial pain which may be evoked by gastro-intestinal and other hæmorrhages.

Acute Hæmorrhage. This can be divided roughly into five degrees, requiring different treatment

(1) Losses up to 500 ml (one "bottle" – 75 g. of hæmoglobin) with little or no fall in the systolic blood pressure Readily replaced and generally speaking fluids by mouth is sufficient treatment

(2) A loss of 1 000 ml is sufficient to cause a slight fall in blood pressure Intravenous fluid including blood will aid recovery but is still not essential

(3) A 1 500 ml. loss causes in all probability, a definite fall in blood pressure to around 100 mm of mercury Recovery unaided is still possible but the administration of plasma—were it free from the present risk of causing homologous serum jaundice—or better blood given as soon as possible will remove the risk to life and speed recovery

(4) A loss of 2,000 ml (four "bottles" 300 g. of hæmoglobin) is likely to cause a rapid fall in the blood pressure to a systolic level of under 100 mm. of mercury with later *a fall to lower levels. Spontaneous recovery* becomes less likely at this stage but the outlook is good if blood is given sufficiently early and even plasma is likely to be sufficient

(5) Hæmorrhages in which over 2,500 ml. are lost cause a fall of blood pressure to dangerously low levels (60 to 70 mm of mercury) and recovery is possible only if blood plasma a plasma substitute, dextran or polyvinyl pyrrolidone is given almost at once. Dextran a solution containing a carbohydrate of very high molecular weight and the polyvinylpyrrolidone Plasmosan with a molecule sufficiently large to be retained within the vascular system, can be used in place of plasma and are free from the risk of homologous serum jaundice

Naturally simple uncomplicated blood loss is unusual and the associated trauma must be taken into account. Depending upon its severity these grades should be "stepped back" one or more degrees. Thus the remarks applied to the loss of a litre should be applied to the loss of 500 ml. during an operation of some severity

SHOCK

Pathology To simplify the question, shock has only been mentioned in relationship to hæmorrhage but shock can result from many other causes serious injuries surgical operations burning freezing asphyxia heat stroke serious infections such as diphtheria, pneumonia, pancreatitis peritonitis, and gas gangrene from poisoning reactions to mismatched transfusions and various biochemical upsets such as diabetic coma. Despite all these varied causes the basis of the condition is uniform, a severe depression of tissue metabolism.

Particularly after serious injuries the patient may collapse almost immediately with such signs as a cold, pale skin, a thready pulse depressed respiration, lowered muscular tone and even loss of consciousness.

Such an attack is almost certainly due to a redistribution of the blood from nervous stimulation. Sometimes this arises from pain at the site of the injury but very often the origin is psychological, for the attack is exactly the same as the fainting attack *induced by an unpleasant sight.* The term primary shock has been applied, but these attacks are better called *vasovagal attacks* for usually they pass off before true shock becomes apparent, although sometimes the one leads straight into the other

The Mechanism of Shock Shock has been defined as "a syndrome resulting from depression of many functions, but in which reduction of the effective circulating volume and blood pressure are of basic importance and in

which impairment of the circulation steadily progresses until it eventuates in a state of irreversible circulatory failure."

Although there is usually an interval between the injury and the onset of true, or as it has been called, secondary shock, the processes leading to shock start at the time of the injury and cardiovascular hæmodynamic and biochemical changes accumulate. At first compensatory mechanisms provide against these changes and sustain the tissues despite the growing opposition. The only exceptions to this sequence are in extremely severe injuries when shock develops almost at once and in the type of injury caused by crushing of the tissues by a heavy weight, where the effects are relatively slight until the weight is removed. Thereafter as the circulation is restored to the injured part, it would appear that some damaging product from the injured tissues possibly adenosine triphosphate, enters the circulation and causes shock.

In mild cases the compensatory mechanism is presumably adequate, the nervous stimulation dies down, or the circulating chemical substance is in some way neutralized, and shock does not develop. If the process is more severe there comes a point when the compensation breaks down quite suddenly the peripheral vasoconstriction, even augmented by extension to certain organs such as the kidneys, can no longer maintain the blood-pressure, the fluid balance between the tissues and the blood is upset and the accumulating acid metabolites so depress the alkaline reserve of the blood that an acidosis develops.

Even essential tissues no longer receive an adequate blood supply and the cellular metabolism is usually further depressed by toxic substances, sometimes the shock producing agent itself but more often abnormal metabolites of endogenous origin. For a time the disturbance is reversible, but after a certain point it becomes permanent and even the complete restoration of the circulation would not restore life to the dying tissues.

If the brain or other vital tissues are involved in this way death is inevitable, but as we have already seen with hæmorrhage, it may be the kidneys that suffer the severest damage giving rise to anuria followed in some cases by recovery in others delayed uræmic death.

The shocked patient is weak, with a grey pallor and a cold sweat, his pulse is thready and he complains of thirst. Usually an important and early sign is that the blood-pressure is lowered, but more rarely there is no fall until the later stages. Pulse tracings show a sharp systolic rise followed by an equally sharp fall, indicating a loss of the normal vascular elastic recoil. The metabolic rate is depressed, there is acidosis, and the venous blood shows an increased degree of reduction of the hæmoglobin. Sometimes there is hæmoconcentration, but in other cases there is hæmodilution.

The clinical findings suggest and it can be confirmed, that although the basic changes in shock are at least similar the mechanisms by which they are produced may differ fairly considerably

The loss of blood volume found after hæmorrhage is easy to understand but where there is no substantial external or even obvious internal loss of blood a fall is more difficult to explain. One type of reduction occurs through sequestration of a large quantity of blood in dilated capillary beds, especially in the portal and pulmonary circulations another is due to a loss of plasma from seepage through the walls of damaged capillaries, particularly in a traumatized area. These changes, the result of a nervous reflex

or some circulating toxic substance affect the vascular tone and the vascular permeability respectively in the two types

In the case of skeletal injuries hæmorrhage into the tissues local seepage and sequestration all occur but with burns the mechanism is more closely related to hæmorrhage for a large quantity of fluid is lost through weeping from the surface The resulting hæmoconcentration by increasing the viscosity of the blood further impedes the effective circulation In certain forms of shock, particularly those associated with medical conditions such as pneumonia there is no demonstrable loss of blood volume and the shock is due to an acute toxic circulatory failure This condition is partly due to the normal volume of blood being unable to fill a dilated vascular bed and partly to a toxic weakening of the cardiac action

The falling of the blood pressure is possibly the worst sign for it usually indicates an increasing degree of shock. A gradual decrease in the systolic pressure down to between 70 and 80 mm of mercury may be recovered from but there is always the danger of pneumonia or anuria from the lower nephron syndrome.

If after a slow decline the blood pressure falls suddenly it probably means that the irreversible stage has set in and that no further treatment is of any avail for at this stage even restoration of the blood volume by massive transfusion can be of no more than transient benefit

A rapidly declining blood pressure is naturally of worse significance than is a gradual fall but effective treatment may arrest the process in the earlier stages.

Treatment of Shock A patient in a vasovagal attack is placed in the recumbent position loosening any tight clothing especially around the neck, and is kept warm by blankets and hot water bottles. Alcohol should be avoided after injuries or other conditions liable to produce true shock, for the vasodilatation induced will defeat the compensatory mechanisms. In more serious cases placing the head below the level of the rest of the body may help and the vasoconstricting drugs, particularly methylamphetamine hydrochloride (Methedrine) an intravenous infusion of *l* noradrenaline solution 1 in 250 000 or even a blood transfusion may be necessary to restore the circulation.

While there is a definite interval between a mild vasovagal attack and the onset of shock, the more serious and prolonged attacks merge into the state of true shock.

In surgical practice the best method is to avoid shock after operations by good anesthesia, as little trauma as possible replacing any substantial loss of blood, and stopping any fall in the blood pressure which indicates the onset of shock, by blood transfusion

If the state of shock is already established it has to be treated at once. General measures such as the removal from or the protection against shocking influences, including heat, cold or exposure, must not be overlooked The patient should be made comfortable and his fears allayed. His body must be kept reasonably warm whilst leaving the limbs rather cold to reduce the metabolic changes in the tissues with a diminished blood supply The foot of the bed should be raised to give the brain the greatest possible supply of blood, and if operation is not contemplated moderate quantities of fluid given by mouth.

Drugs are of restricted use at this stage, and vasodilators, including

alcohol are definitely contra-indicated The giving of intravenous saline is probably the best immediate measure, for not only does it insure an adequate supply of fluid but it provides a vitally important, even if it is only temporary increase in the circulating blood volume. Physiological saline helps any case but is of particular value where hæmoconcentration is impeding the blood flow Not more than 500 to 1 000 ml. of saline should be given for it leaves the circulation rapidly and tends to cause pulmonary œdema The saline should be followed almost always by blood to consolidate the improvement.

When it is known that there has been considerable blood loss or there is evidence of hæmodilution a blood transfusion given at once is the best treatment, but in the cases with obvious hæmoconcentration plasma, or one of the plasma substitutes, are possibly preferable. A sample of blood for any future cross matching should always be taken before giving dextran which causes marked rouleaux formation simulating agglutination.

Although a small quantity of fluid may have a striking effect upon shocked patients, there is a tendency to relapse particularly after saline solutions and to get a sustained improvement quantities of blood or plasma in the region of 1 000 to 1,500 ml are required. When there are facilities for continuous control especially circulatory collapse under anæsthesia, *l* noradrenaline, a powerful vasoconstrictor may be used This is added to an intravenous infusion whether of blood plasma or saline to give a concentration of 4 mg. per litre. The rate of flow is controlled to give about 1 ml. (approximately 20 drops of blood or 25 of saline) in the first half minute. As the action becomes apparent by a rise in the blood pressure, the rate of flow is adjusted to maintain the desired level. The danger is that if *l*-noradrenaline is withdrawn suddenly there will be a precipitate fall in the blood-pressure. Various methods of withdrawal have been devised, including gradually replacing with methylamphetamine which can later be stopped more easily

In extreme cases of shock, transfusion to be effective may have to be given by the intra-arterial route and intravenous hydrocortisone in 100 mg. doses may be tried

BLOOD DISORDERS OF SURGICAL IMPORTANCE

Hæmorrhage Due to Blood Disorders. Blood disorders may play a part both in spontaneous hæmorrhages and in those which follow trauma, but in many cases they are so intimately connected with certain vascular changes that the two must be considered together

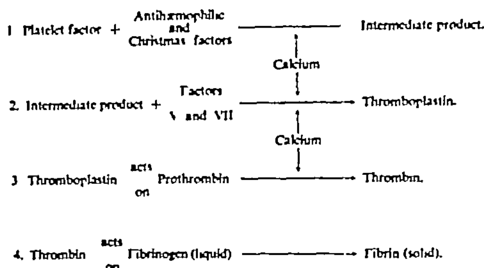
Spontaneous hæmorrhage may be due to erosion of a vessel by some pathological process to some change in the vessel wall which renders it unduly fragile so that it breaks under normal stresses, or to some defect in the clotting mechanism so that the ordinary insignificant leaks of blood which must occur from time to time are exaggerated into definite hæmorrhages.

The hæmorrhages may occur in any part of the body but those of particular surgical importance are hæmaturia, hæmarthrosis, and various subcutaneous intramuscular and retroperitoneal hæmatomata

In traumatic hæmorrhage, defects in the clotting mechanism interfere with the normal process for stopping the bleeding so that the wound continues to ooze for hours.

In hæmorrhage from a large vessel the elastic recoil of the various coats reduces the opening and it is sealed by a firmly retracted clot while in trivial injuries where the bleeding comes from the smallest vessels particularly the capillaries the hæmorrhage is stopped by the contraction of the small vessels and the formation of platelet thrombus For the former process to be effective not only must the vessel be in good condition but the clotting of the blood must also be adequate

TABLE A. THE CLOTTING MECHANISM.



The clotting of normal blood at body temperature takes place in about five minutes and the process can be divided into four stages (Table A) Initially the platelets adhere to a water wettable surface, rupture and liberate a substance which combines with the plasma factors, antihæmophilic globulin and Christmas factor in the presence of calcium to form an intermediate product. This intermediate product, which can be replaced in the clotting mechanism by tissue juice links with Factors V and VII to form thromboplastin. In turn this activates the prothrombin of the plasma and converts it to thrombin Finally the thrombin condenses the liquid fibrinogen of the plasma to fibrin threads, which enmesh the red corpuscles in a gelatinous blood clot Subsequently the fibrin threads contract, and in about half an hour the clot starts to shrink and to express the serum. When fully retracted the clot is firm and only occupies a little over half the volume it did at first. In vivo while a normal clot remains adherent to the surrounding structures and contraction of the fibrin threads draws the tissues together a defective clot may have no such action

Defective or delayed clotting can be due to complete or partial absence of the various factors involved in the clotting mechanism, to inhibitors blocking the process at any stage or to a fibrinolysin removing the fibrin as it forms.

Defects of clotting can be measured in several ways, but with all the factors involved there are many sources of error The *clotting time* is a crude measure of the speed with which whole blood clots. In Lee and White s method three 1 ml. samples of freshly-drawn venous blood are kept at 37° C. The tubes are tipped at half minute intervals until they can be inverted

The time taken for the blood to clot in each is noted and the average taken as the clotting time. The normal limits for this method are five to ten minutes.

The quantity of prothrombin can be estimated by the *prothrombin time* a test measuring the time oxalated plasma takes to clot from the moment of recalcification when the factors other than the prothrombin *are supplemented to give optimal quantities.* Normally the time is about 14 seconds and 90 per cent of the prothrombin is utilized during clotting.

The prothrombin time is prolonged in prothrombin deficiency fibrinogenopenia, and deficiencies of Factors V and VII It is within the normal limits in hæmophilia Christmas disease and in most hæmorrhagic disorders caused by circulating anticoagulants The further identification of the defect can be made by means of the *thromboplastin generation test* In this a mixture of aluminium hydroxide treated plasma, serum, a platelet suspension and calcium chloride is incubated At intervals samples are transferred to citrated normal plasma to test for thromboplastin formation The treated plasma contains Factors V and antihæmophilic globulin, and the serum Factor VII and Christmas factor By substituting the abnormal plasma or serum for the normal, the defect can be localized.

The amount of fibrinogen present in the plasma can be judged from the heaviness of the precipitate formed when 2 ml. of plasma are added to 1 ml of saturated ammonium sulphate or from the rate of clotting by thrombin. The fibrinolytic activity of the plasma can be estimated from the speed with which it dissolves a fibrin clot, while inhibitors such as circulating anti coagulants can be detected by demonstrating that the plasma delays the clotting of normal plasma.

Defects in the mechanism for stopping bleeding from trivial injuries can be detected by the test known as the *bleeding time* A small cut is made in the lobe of the ear and the drops of blood which form are removed by touching them with a piece of filter paper care being taken not to touch the skin. Normally the blood stops flowing in two to five minutes. An increased bleeding time indicates a lack of platelets or a capillary defect

Spontaneous hæmorrhages tend to start from the arterial side of the capillary loops as this is the point where the greatest intravascular pressure relative to the strength of the vessel walls, is liable to develop and when Hess s capillary resistance test is positive it can be shown that the petechiæ develop at this point.

The platelets, of which there are normally over 250,000 per c.mm., can be counted in the ordinary cell counting chamber in a sample of blood collected without contact with water wettable surfaces and then suitably hæmolysed, diluted and stained.

Hess s test consists of congesting the arm for a period up to six minutes in negative cases, by means of a blood pressure cuff inflated to a little above diastolic pressure. The anoxæmia exaggerates any capillary weakness and if the number of petechiæ developing within a circle 5 cm. in diameter exceed ten to twenty the test is considered to be positive.

Hypoprothrombinæmia. Very little prothrombin is required for clotting, and except when the deficiency is severe the blood clots within the normal time, the defect however can be demonstrated by a prolongation of the prothrombin time Other examinations, such as the bleeding time the platelet count and Hess s test, give normal results, but sometimes there is

poor retraction of the clot Very rarely hypoprothrombinæmia is a congenital condition

Vitamin K deficiency leading to lack of prothrombin is seen in hæmorrhagic disease of the newborn Normally the child receives a small store from its mother to tide it over until the bacterial flora of the intestine is established and the vitamin produced by this means If the store is inadequate the consequent lack of prothrombin leads to bleeding in various parts of the body The giving of vitamin K by injection will stop the condition but it takes time to act and in serious cases it may be necessary to supply the prothrombin by blood transfusion

A similar condition may be met with in adults under two separate circumstances During treatment with antibiotics which destroy certain intestinal organisms the flora may be so altered that an adequate quantity of the vitamin is no longer available Again where there is an insufficient amount of bile entering the intestine in obstructive jaundice or biliary fistula or where the intestinal wall is pathologically altered, as for example in the sprue syndrome the absorption of vitamin K may be defective

The prothrombin is normally formed from the vitamin in the liver but in gross liver injury this process may be so hindered that the blood prothrombin falls to low levels.

Hypoprothrombinæmia together with Factor VII deficiency may be produced artificially by giving drugs of the dicoumarol group or the synthetic anticoagulant phenindione (Dindevan) or even large doses of salicylates The dicoumarol derivatives and their synthetic counterparts are used therapeutically to lower the coagulability of the blood in an endeavour to prevent extension of thrombosis After an initial dose of 200 mg. of phenindione a maintenance dose of between 50 and 150 mg. a day is given to keep the prothrombin—Factor VII level low as estimated by a prolongation of the prothrombin time to between two and two and a half times the normal.

Hæmophilia and Christmas Disease In both hæmophilia and Christmas disease a prolonged clotting time, although characteristic is not always found When present the blood may remain fluid for several hours Only in anaphylactic shock and in the conditions associated with a circulating anticoagulant, congenital or acquired afibrinogenæmia and a few rare deficiencies is there a similar complete or almost complete lack of clotting

In these two conditions the underlying errors the lack of antihæmophilic globulin and the lack of Christmas factor are quite different so that mixtures of the two bloods clot normally These defects do not interfere with the prothrombin time, where ready formed intermediate factor ("brain thromboplastin") is one of the reagents, but the utilization of prothrombin during clotting is diminished The thromboplastin generation test is used to distinguish the two conditions. In hæmophilia the treated plasma is abnormal, while in Christmas disease the serum is defective

The conditions occur exclusively in males and are inherited through the females as a sex linked recessive. The main clinical feature is the excessive bleeding which follows any injury greater than that which can be stopped by platelet thrombus, for curiously the bleeding time is normal Once started, the bleeding may continue for many hours and quite a small wound may lead to a fatal hæmorrhage.

In patients with hæmophilia, or Christmas disease, operations should be undertaken only when absolutely imperative, and then after attempts

have been made to raise the antihæmophilic globulin or Christmas factor to over 30 per cent. of their normal levels

In addition to the traumatic hæmorrhages there is also a tendency to spontaneous hæmorrhage, or at least any causative trauma must have been so slight that it passed unnoticed. Bleeding into the joints, particularly the knee joint, is the most characteristic, but there can be hæmorrhage in almost any part of the body including the alimentary and genito-urinary tracts. Bleeding into the tissues of the neck is liable to cause sufficient pressure on the trachea to obstruct the airway and necessitate intubation or even an emergency tracheotomy

The treatment is essentially to avoid any form of trauma. When there is actual bleeding, the local application of purified thrombin on a dressing kept in position by moderately firm pressure is often sufficient to stop the bleeding. Styptics, which damage the tissues, or excessive pressure must be avoided for the necrosis they may cause leads to further bleeding. External bleeding, unless very severe, is not to be feared for the blood lost can be made good by transfusion, but internal bleeding may call for immediate treatment. The transfusion of fresh blood is the main standby in hæmophilia, for the antihæmophilic globulin is labile and disappears on storage. The danger of overloading the circulation has to be avoided and fresh or specially prepared dried plasma may be used if available. Unfortunately some hæmophilics develop antisubstances to the antihæmophilic globulin so that subsequent transfusions are valueless. In a few instances antihæmophilic globulin of animal origin has been prepared specially and used to tide a patient over a crisis such as an abdominal operation. Unfortunately antibodies to the animal protein develop rapidly and limit the effectiveness of such preparations.

In Christmas disease the treatment is rather easier for the factor is more stable and is present in stored blood in plasma and even in serum.

Deficiencies of Factors V and VII are very rare They are non-sex linked, but otherwise correspond to hæmophilia and Christmas disease in many features.

Hypofibrinogenæmia. A similar condition is due to lack of fibrinogen This occurs in the rare condition of congenital afibrinogenæmia, and occasionally in various forms of liver damage, and bone marrow disorders, including pernicious anæmia and myelogenous leukæmia. To cause defective clotting the fibrinogen must be almost completely absent and it is rarely or never a significant factor in the hæmorrhages associated with these latter conditions.

In an even more dangerous condition hypofibrinogenæmia and a fibrinolysin are present together This occurs particularly when liquor amnii enters the circulation following premature separation of the placenta. It has also been reported after lobectomy thoracotomy gastrectomy and prostatectomy when it is presumed that tissue particles entering the blood stream have activated a fibrinolysin precursor The condition is often fatal despite transfusions, but large quantities of fibrinogen given intravenously may tide the patient over the crisis. An attempt should be made to keep the plasma fibrinogen level above 50 mg. per 100 ml.

Circulating anticoagulants are fortunately very rare for the treatment is not usually satisfactory

Scurvy Scurvy due to vitamin C deficiency with its lethargy purpuric

eruptions and hæmatomas must not be overlooked as a cause of unexplained bleeding In this country vitamin C deficiency occurs rarely and then in old people on meagre diets or younger individuals who have followed a rigid "ulcer diet" with obsessional enthusiasm.

Thrombocytopenic Purpura This condition is considered in Chapter 47 in connection with diseases of the spleen

Hereditary Hæmorrhagic Diathesis. If the clotting time and the platelet count are normal but the bleeding time is prolonged the purpura must be due to a vascular change Such a defect is the basis of this condition

This hereditary diathesis is transmitted to either sex and is manifest by hæmorrhages from the mucous membranes seldom accompanied by a tendency to purpuric eruptions Although the bleeding time is prolonged the clot retraction defective and Hess's test positive the clotting time is normal and there are adequate numbers of platelets. This is a condition often recorded as hæmophilia in the female

Fortunately the bleeding tendency diminishes after childhood for there is always the risk that a hæmorrhage may be fatal Blood transfusion may be necessary if the bleeding is severe but splenectomy is of no value

Hereditary Hæmorrhagic Telangiectasia. Hereditary hæmorrhagic telangiectasia is a dominant condition transmitted to both sexes. The telangiectasia are small nodules of dilated capillaries and venules scattered throughout the tissues, including the skin and mucous membranes They are very fragile and bleed from slight trauma.

The lesions are quite characteristic small bright red slightly raised nodules which fade on pressure with a glass slide They should be looked for on the skin and mucous membranes in any unexplained hæmorrhage or even anæmia of the post hæmorrhagic type.

The condition causes the sufferers a great deal of inconvenience and even ill health while they permanently carry the risk of a fatal hæmorrhage. Individual telangiectases can be treated by electrocautery or escharotics, but the condition is normally too widespread for systematic eradication Bleeding from the nose may be controlled by packing.

Bleeding and purpura are also associated with other skin diseases

Leukæmia. Leukæmia is a condition in which the white cell precursors in the bone marrow for the granulocytic series and the lymph nodes and spleen for the lymphocytic and monocytic cell types undergo abnormal proliferative changes and usually pour out into the circulation numbers of leucocytes greatly in excess of the demands of the body

Leukæmia may be chronic, subacute or acute and may affect any of the main cell types.

Chronic Myelogenous Leukæmia. Huge numbers of neutrophils—segmented polymorphs metamyelocytes, myelocytes and even premyelocytes and a few myeloblasts appear in the peripheral blood. As the bone marrow proliferates the increasing intra-osseous pressure gives rise to "bone pains" sometimes suggesting such diagnoses as arthritis, osteomyelitis, and various conditions which are associated with bone pains, such as Malta fever After a time changes may be quite obvious by X ray and as the condition progresses, extreme bone absorption and even spontaneous fractures occur

The white cell proliferation in the marrow is partly at the expense of the red cell precursors, giving rise to a progressive and severe anæmia, while

interference with the megakaryocytes so reduces the number of platelets being produced that bleeding is often a prominent symptom.

Lymph node and splenic enlargement are usually marked features, and there is commonly infiltration of the other organs and even of the skin with the leukæmic cells. The enlargement of the liver is sometimes a striking feature but the infiltrative changes are seldom severe enough to cause jaundice.

Hæmorrhages particularly intestinal hæmorrhages may be a serious complication and greatly aggravate the anæmia, while not infrequently bleeding, for example from the genito-urinary tract may be the first sign of a leukæmia. Thrombosis is a feature of some cases and sometimes priapism occurs from thrombosis of the corpora cavernosa.

The enormous acceleration of leucocyte production and destruction increases the general metabolic rate and causes fever nervousness, and abnormal perspiration, leading to severe cachexia.

Chronic Lymphatic Leukæmia The symptoms and signs in this are similar with only slightly different emphasis. The blood shows enormous numbers of lymphocytes which are almost exclusively of the mature type for example 250 000 white cells per c.mm with over 95 per cent. of lymphocytes. Lymph node enlargement is perhaps more prominent and skin lesions are more frequent

Acute Leukæmia The upset to leucocyte formation is more fundamental and mature leucocytes almost disappear from the peripheral blood Myeloblasts and early premyelocytes dominate the picture in the myelogenous form, and lymphoblasts in the lymphatic variety but in the monocytic type most of the cells are fairly mature monocytes.

The whole disorder is much more violent than in the chronic type Fever prostration hæmorrhages, rapidly developing anæmia and agranulocytosis often with gangrenous ulceration of the mucous membranes especially the throat are the prominent features while splenic and glandular enlargement are less obvious except in the monocytic type.

As in the chronic varieties, acute leukæmia is one of the causes of spontaneous hæmorrhages, particularly from the genito-urinary tract, and changes in the bones produce signs and symptoms suggesting at times caries of the spine, brucellosis or Still s disease. Bone tenderness is usually present, especially at the lower end of the sternum and the resorption leads to osteoporosis and even spontaneous fracture collapse of a vertebra being especially characteristic.

The blood rarely shows a high leucocyte count and not infrequently it is within the normal limits. The blood film, however is usually unmistakable on account of the uniformity and the gross immaturity of the cells, *for the myeloblasts or the lymphoblasts with their disproportionately large,* pale nuclei containing several nucleoli, and their rim of clear blue cytoplasm devoid of any characteristic granules, dominate the picture. The severe anæmia which always develops is an important diagnostic point.

There are also peculiar leukæmias, particularly the aleukæmic forms where the changes are limited to the marrow or to the lymph nodes and the number of white cells in the peripheral blood is normal or even reduced while only a few or no abnormal cells can be found. A marrow puncture is required to make the diagnosis.

There is no specific treatment. The object of any treatment employed should be to keep the leukæmic patient *comfortable in mind and body*

ambulatory and if possible at work Transfusions may be needed to correct any associated anæmia Should this prove insufficient owing to hæmolysis possibly due to some as yet unidentified antigen antibody reaction and a not infrequent complication of leukæmia cortisone or prednisone may reduce the rate of cell breakdown Ample dosage must be used 150 to 300 mg of cortisone or 40 to 60 mg of prednisone daily Occasionally splenectomy is of value Hæmorrhage from lack of platelets is treated similarly

Treatment with X rays the cytotoxic or antagonistic drugs (Table B) can produce spectacular if temporary remissions Life is made more bearable and perhaps prolonged if only for a limited time These methods have their own dangers and the decision to employ them must be made with some restraint and only when the symptoms warrant intervention In chronic leukæmia irradiation of the spleen improves the patient s condition for weeks or months and even the anæmia may diminish but the condition always returns and eventually becomes resistant to treatment. Acute leukæmia is not benefited by irradiation The dosage of irradiation varies from one clinic to another and is in the region of 50 to 100 r given two or three times a week up to a total of 200 to 600 r Some believe that the smallest dose capable of producing a remission is the correct measure so that the larger doses can be reserved for later The radioactive phosphorus isotope ^{32}P given intravenously can be used in the place of X rays.

Recently a number of cytotoxic drugs including triethylenemelamine (TEM) and Myleran have been developed (Table B) These, like X rays have a greater effect upon the rapidly proliferating abnormal cells than upon the normal tissues and can cause spectacular remissions in chronic leukæmia comparable to or even more complete than those induced by X rays.

TABLE B

Treatment	Type of Leukæmia			
	Chronic		Acute	
	Myelogenous	Lymphatic	Myeloblastic	Lymphoblastic
Irradiation				
X-ray	YES	YES	NO	NO
^{32}P	YES	SLIGHT	NO	NO
Mustards				
HN2	SLIGHT	YES	NO	NO
T.E.M	SLIGHT	YES	NO	NO
Chlorambucil	NO	YES	NO	NO
Busulphan (Myleran)	YES	NO	NO	NO
Demecolcin	YES	NO	NO	NO
Urethane	YES	SLIGHT	NO	NO
Antagonists (Folic acid)				
Aminopterin	NO	NO	YES	YES
(Purine)				
6-Mercaptopurine	? NO	NO	YES	YES
Adrenal hormones				
Cortisone, prednisone	NO	YES	YES	NO

Acute leukæmia has also come within the scope of drug treatment and long remissions can be induced in a proportion of cases, especially in children, by the use of antagonists to essential factors in cell metabolism particularly the antifolic acid and the antipurine drugs (Table B) These have the advantage that if toxic signs appear the particular factors being antagonized, folic acid or possibly purine ribotide or riboside can be given to stop the action.

The earlier forms of cytotoxic and antagonistic drugs were unpleasant and dangerous to use for the toxic and therapeutic doses were close but recent additions are more readily controlled. Unfortunately these drugs have the same drawback as X-rays and after an interval the abnormal cells return, the lymph nodes swell again and the spleen enlarges to its old size and even beyond while after two or three remissions complete resistance to the drug develops.

Polycythæmia. This is a condition including two distinct entities. There is a simple increase in red cells which develops in response to oxygen deprivation and corresponds to a simple leucocytosis, and there is a variety without any obvious cause, which in many ways resembles a leukæmia.

The simple variety develops physiologically in people who live at high altitudes and pathologically in certain cases of congenital heart disease and chronic pulmonary disease with cyanosis. If the oxygen supply is restored the polycythæmia disappears.

The other form, or sometimes it is called the true polycythæmia or Osler Vaquez's disease, is characterized by a ruddy cyanosis, splenomegaly and polycythæmia. The blood volume is greatly increased and there is dilatation of the skin and other capillaries, while the rise in the viscosity of the blood leads to a slowing of the flow and a greater degree of reduction of the hæmoglobin than normal.

Hæmorrhages and thromboses are common and bleeding from the mucous membranes, from the gastro-intestinal respiratory and urogenital tracts is common. Even perirenal and intra abdominal hæmorrhages may occur and these and mesenteric and portal thromboses may simulate other abdominal crises.

The various nervous complications are more of medical than surgical interest, but there is a surgical aspect in the association with peripheral vascular disease, which can lead to claudication, Raynaud's disease and even complete occlusion with gangrene.

The treatment is directed towards reducing the number of blood corpuscles and venesection is probably the best method for the immediate relief symptoms Reducing the corpuscles by destruction through the use of the hæmolytic agent, phenylhydrazine, or by decreasing the rate of production by X-raying the bones or by giving radioactive phosphorus can keep the patient in moderately good health for long periods.

Abdominal Crises in Blood Disorders. In addition to gall stone colic due to pigment stones in congenital or acquired hæmolytic jaundice acute abdominal pain occurs in several other blood disorders.

Hæmorrhage into the wall of the intestine or into the retroperitoneal tissues can occur in purpuric conditions in hereditary multiple telangiectasia, in hæmophilia, in leukæmia and in polycythæmia and may so closely simulate other abdominal crises that the surgeon is tempted to open the abdomen.

Colics of considerable severity are associated with acute hæmolytic

anæmia the hæmolytic crises of chronic congenital and acquired hæmolytic jaundice acute porphyria either due to an inborn error of porphyrin metabolism with acute exacerbations or to a metabolic upset caused by certain drugs, particularly the barbiturates the carbohydrate indigestion associated with severe anæmias possibly the onset of central nervous symptoms in pernicious anæmia and chronic lead poisoning where a type of chronic hæmolytic anæmia with punctation of the young basophilic cells is accompanied by a "lead line" on the gums changes in the bones and colic.

Infarction of the spleen is a not infrequent complication of leukæmia and splenic anæmia and in addition to pain especially in the left hypochondrium there may be a friction rub Rupture of the spleen is a rare complication of malaria and is even rarer in glandular fever

Intestinal obstruction can be simulated by the swelling of the mesenteric lymph nodes in glandular fever or leukæmia or may actually take place from infiltration of the bowel wall by the leukæmic cells. Glandular fever is a benign condition with glandular enlargement painful ulceration of the throat fever the presence of abnormal lymphocytes in the blood stream and the formation of curious antibodies which agglutinate the red cells of various animals, particularly the sheep and are detected by the Paul Bunnell test. Some of these changes may be missing.

Mesenteric thrombosis although commonly due to vascular disease may occur in those blood disorders associated with a tendency to thrombosis, particularly polycythæmia leukæmia and some types of hæmolytic anæmia. This is a true emergency requiring operation for resection of the affected part of the bowel.

Bone Changes in Blood Disorders. Owing to the close relationship between the bone marrow and the encasing bone it is not surprising that there are often bony changes in blood disorders. Palpable tumours may develop and spontaneous fractures can occur but most often the changes are more subtle, a sclerosis, an osteoporosis, or a widening of the marrow cavity and are only visible on X ray examination.

Marrow changes early in life when the bones are in a more dynamic state naturally produce changes fairly readily and characteristic hyperplastic bone changes are found in such conditions as sickle-cell and Mediterranean anæmia. The former is a disorder affecting negroes and caused by an inherited abnormality of the hæmoglobin which makes the cells assume curious shapes when the oxygen tension is reduced In many cases this leads to hæmolysis and fairly severe anæmia. Mediterranean anæmia is a condition affecting people of Mediterranean stock in whom an abnormal thinness of the corpuscles and a tendency to hæmolysis results in erythroblastosis and anæmia. Osteoporosis can be due to the *sprue syndrome* including sprue, idiopathic steatorrhœa and cœliac disease, and these are usually associated with anæmia. In leukæmia, as already mentioned tumour like lesions of the bone, subperiosteal infiltrations, areas of osteoporosis and even articular changes are not uncommon findings

In the lipoid dystrophies, Gaucher's disease and Hand Schüller Christian's disease, there may be extensive bone change. Gaucher's disease is a chronic disorder which although it sometimes first appears in adult life, is of an inherited nature. In it the accumulation of large quantities of an

Chapter 5

WATER AND ELECTROLYTE DEFICIENCIES IN SURGERY

Introduction

Inadequate correction of disturbances of electrolyte and water balance is probably responsible for more deaths and protracted convalescence in gastro-intestinal surgery than is lack of operative surgical skill. The physiology and biochemistry are complex but the surgeon must have enough knowledge of the subject to enable him to treat patients on rational lines.

The Fluid Compartments of the Body *Magnitude* The total water content of the body normally amounts to between three-quarters of the body weight in the case of thin persons and two-thirds of the body weight in obese persons. In infants, the water content may be as high as four fifths of the body weight This body water is contained in two distinct compartments differing greatly in size and in the nature of the substances in solution. The smaller of these, and from the surgeon's point of view the more important, is the extracellular compartment amounting to approximately one-fifth of the body weight. The remainder of the body water is within the cells, *i.e* in the intracellular compartment. Since the water of the smaller extracellular compartment includes the water of the circulating plasma, a reduction in the extracellular fluid volume may be associated with *such a fall in the volume* of circulating plasma that either peripheral circulatory failure or renal failure, or both may result.

It is essential that the surgeon should be able to compute the approximate normal magnitudes of the total body water the extracellular water and the plasma water in any individual patient. Table A illustrates the values computed in the above way for four individuals of differing size.

TABLE A

Calculation of Fluid Compartments of the Body

TOTAL WATER OF BODY = 66-75 per cent. BODY WEIGHT
(Upper level in thin, lower level in fat persons, 80 per cent. in infants)
EXTRACELLULAR FLUID = approx. 20 per cent. BODY WEIGHT
(This includes plasma which amounts to approx. 5 per cent. body weight)

	Weight	*Extracellular Fluid*		*Intracellular Fluid*	*Total H_2O*
		Plasma	*Interstitial Fluid*		
Adult	11 stones = 70 kg.	3 5 litres	10-5 litres	36 litres	50 litres
Adult	9 „ = 58 kg.	2·9 „	9 „	28 „	40 „
Child	4½ „ = 29 kg.	1 5 „	4 5 „	14 „	20 „
Infant	8 pounds = 3·6 kg.	180 ml.	540 ml.	2,280 ml.	3 „

As will be seen later when gastro-intestinal secretions are lost to the body the fluid loss is borne mainly by the smaller extracellular compartment The importance of a knowledge of the normal magnitude in every individual case is therefore evident when it is appreciated that this may vary from 720 ml in the infant to 14 litres in the adult of 70 kg (11 stone)

Composition Each of the fluid compartments of the body contains salts in solution and the concentrations of these salts are such that except for small but important differences maintained by biological processes all the fluid compartments and all the secretions except sweat have the same osmotic pressure *The principle ions of the extracellular fluid are* sodium chloride and bicarbonate while those of the intracellular fluid are potassium protein and organic phosphate derivatives The chemical composition of the interstitial fluid is almost the same as that of plasma except that the former contains practically no protein Chemical analyses of the plasma for sodium bicarbonate and chloride ions therefore give fairly accurately the composition in regard to these ions of the extra cellular fluid Ordinarily the chemical composition of the intracellular fluid is not directly measurable but needs to be derived by indirect methods, *i.e* by balance experiments.

Fluid Balance Under normal conditions the fluid output just balances *the fluid intake in the way shown for two patients in Table B*

TABLE B

Water Balance for Adult of Average Size

Intake		*Output*	
As fluid drinks	say 1 450 ml.	Saliva	1,500 ml.
As moisture in food	800 ml.	Gastric secretion	2,500 ml.
H_2O formed by oxidation of food	350 ml.	Bile	500 ml.
		Pancreatic juice	700 ml.
		Intestinal secretion	3,000 ml.
			8,200 ml.
		Almost all reabsorbed normally except	100 ml.
		Insensible perspiration	400 ml.
		Sensible perspiration	200 ml.
		Respiration	400 ml.
		Urine	1,500 ml.
	2,600 ml.		2,600 ml.

All these fluids are derived from extracellular fluid. Compare their volume with 3,500 ml. plasma and 14 000 ml. extracellular fluid.

Water Balance for Infant of 8 pounds (3·6 kg)

Intake		*Output*	
As fluid drinks	say 620 ml.	Alimentary secretions (approx.)	400 ml.
H_2O formed by oxidation of food	80 ml.		
		Almost all reabsorbed normally except	20 ml.
		Insensible perspiration, sensible perspiration and respiration	180 ml.
		Urine	500 ml.
	700 ml.		700 ml.

The important features to note from this balance sheet are

(1) There is an inevitable water loss of approximately 1 litre per day in adults but less with reduction in body size until it is only of the order of 180 ml per day in the infant This variation of inevitable water loss with body size is important in considering the water balance of any individual case Practically no sodium loss accompanies this water loss since in the absence of excess sweating the loss of sodium in the sensible perspiration will be negligible.

(2) Normally about 8 litres of gastro-intestinal secretion (of the same osmotic concentration as the extracellular fluid) are poured into the gut each day All but about 100 ml. of this is normally reabsorbed, but this will not be the case when there is vomiting, diarrhoea, intestinal obstruction or the presence of a fistula

(3) With a patient on a normal diet, about 800 ml. of fluid are ingested per day as the moisture of food. This will not be available if the patient is unable to ingest food or if he is existing on a fluid diet.

(4) About 350 ml. of water are available each day from the oxidation of foodstuffs even if the calorie value of the food intake is reduced it is unlikely that this inevitable water intake will be appreciably lowered since water of oxidation will still be available from the oxidation of the constituents of the tissues.

(5) Under ordinary conditions the loss of water by extrarenal routes varies but little and the output of urine is varied so that the total output balances the total intake

Water Deficiency

Under temperate conditions, when a person is deprived of water water loss continues by insensible perspiration and in the expired air Apart from very small quantities of sodium lost in the sensible perspiration this inevitable water loss is initially derived from the extracellular fluid. Since there is no corresponding loss of sodium concentration in the extracellular fluid will tend to be increased If no further changes occurred the osmotic pressure of the extracellular fluid would therefore increase above that of the intracellular fluid. However the cell membranes normally behave as if they were relatively impermeable to sodium and potassium and when the solution of high osmotic pressure is separated from the solution of low osmotic pressure by a semi-permeable membrane water must pass from the solution of low osmotic pressure to the solution of high osmotic pressure. (It is now known that cell membranes are permeable to both sodium and potassium ions and that the active excretion of sodium ions by the cell maintain the high concentration of potassium within the cell. The cell membrane thus approximates to a semi permeable membrane) In water deficiency water will therefore pass from the intracellular to the extracellular compartment. By this means the water loss *is shared by the extracellular and the intracellular fluids* There will of course ordinarily be an increased excretion of sodium as sodium chloride in the urine so that the process of

Sodium Deficiency

If intestinal secretions are lost by vomiting by diarrhœa or through a fistula the secretions lost possess the same salts and are of the same osmotic concentration as the extracellular fluid from which they must be derived Under such circumstances the extracellular fluid will be reduced in volume but there will be no alteration in the osmotic concentration No compensating shift of water from the cells to the extracellular fluid can therefore take place Most people who have lost intestinal secretions will have taken fluids and in general will have replaced the sodium-containing fluid by one deficient in sodium There will result a fall in the concentration of sodium chloride in the extracellular fluid but this fall will be partly compensated by two processes

(1) Shift of water from the hypotonic extracellular fluid to the isotonic intracellular fluid Contrary to the state of affairs occurring in water deficiency this shift of water will exaggerate the reduction in volume of the extracellular fluid

(2) The excretion of urine free from sodium chloride so that the resulting loss of water lowers the extracellular fluid volume thereby increasing its salt concentration to a level approaching normal

Thus in sodium deficiency there is always a secondary dehydration of the extracellular fluid either by direct loss of intestinal secretions or if these be replaced by watery fluids, by the secretion of water free from sodium chloride in the urine Thus water loss secondary to sodium deficiency is borne entirely by the extracellular fluid There is consequently an early fall in plasma volume early circulatory failure and early failure of renal function contrasting markedly with simple dehydration in which the water loss is shared by the whole body water and fall in plasma volume is a late phenomenon. Such compensatory changes brought about by excretion of urine free from sodium chloride and by shift of water into the cells minimize the alterations in composition of the extracellular fluid so that the actual sodium loss is always more severe than is indicated by chemical analysis of the plasma.

The essential differences between primary water loss due to deprivation of water and the secondary dehydration associated with sodium deficiency may be illustrated by considering in the first place a man, weighing 11 stone, who is deprived of water for six days He will lose his inevitable water loss (in the insensible perspiration and in his expired air) about 1 litre per day *i.e.* about 6 litres in the six days. His normal intracellular fluid volume is 36 litres and will contribute 4 litres to the water loss. His 14 litres of extracellular fluid will lose 2 litres, and the consequent reduction of that extracellular fluid volume to 12 litres is well tolerated On the other hand if the same person loses 6 litres of intestinal secretion the intracellular fluid volume will be unchanged and the 14 litres of extracellular fluid will lose the whole 6 litres and become diminished to 8 litres Such a drastic reduction in extracellular fluid volume will result in a reduction of the plasma volume to a level at which the circulation is precarious and the renal function grossly impaired Similarly a child of 8 pounds who is deprived of water for forty-eight hours will lose about 360 ml in the expired air and insensible perspiration The 2 25 litres of intracellular fluid will lose 240 ml water and the 720 ml of extracellular fluid only 120 ml

This is well tolerated On the other hand, the same child may lose 360 ml. of intestinal secretion by diarrhœa in a few hours This loss would be borne entirely by the 720 ml of extracellular fluid. Such a loss is inevitably fatal

These differences are illustrated in Table C

TABLE C

Distribution of Water Loss in Water Deficiency and in Sodium Deficiency

Adult 11 *stone* (70 kg.)

	Intracellular Fluid		*Extracellular Fluid*	
	Before	*After*	*Before*	*After*
Deprived of Water for Six Days Total H_2O loss = 6,000 ml.	36 litres	32 litres	14 litres	12 litres
Loss of 6 litres of Intestinal Secretion Total H_2O loss = 6,000 ml.	36 litres	36 litres	14 litres	8 litres

Infant 8 *pounds* (3·6 kg.)

	Intracellular Fluid		*Extracellular Fluid*	
	Before	*After*	*Before*	*After*
Deprived of Water for Six Days Total H_2O loss = 360 ml.	2 25 litres	2 litres	720 ml.	600 ml.
Loss of 360 ml. of Intestinal Secretion Total H_2O loss = 360 ml.	2 25 litres	2 25 litres	720 ml.	360 ml.

Treatment

It cannot be emphasized too much that intravenous therapy is only indicated when a patient is unable to retain fluids by mouth Any patient maintained for more than 24 hours on intravenous fluids containing only electrolytes is therefore starving and can provide his calorie requirements only by utilizing body fat and proteins. All such intravenous infusions, whether isotonic or hypotonic in respect of saline, should also contain 5 per cent. of glucose, which is metabolized within a short time of its entry into the body Some clinicians claim that such glucose containing solutions predispose to venous thrombosis, but there is no valid evidence on this point. It is possible, however that the polythene cannula rather than the metal needle can enable intravenous drips to be continued without difficulty over long periods even of several weeks.

Apart from special requirements, *e g* childhood, diabetes or acidosis due to renal dysfunction and to other urological conditions, three solutions are routinely needed in the light of present knowledge for maintenance of electrolyte and water balance These are

(1) 5 per cent. glucose in water for water deficiency

(2) 5 per cent glucose in 0 2 per cent. saline for mixed water and salt deficiency

(3) 5 per cent. glucose in isotonic (0·9 per cent.) saline for salt deficiency

Sometimes potassium chloride may be added (see below) usually to

solution (3) but as emphasized later the administration of potassium containing solutions may be extremely dangerous In some circumstances e g hæmorrhage or shock blood packed red cells red cells plasma or plasma substitutes are a necessary part of treatment but detailed consideration of this aspect is considered elsewhere

Simple Water Deficiency *The treatment of simple water deficiency is quite different from that of salt deficiency with secondary dehydration,* and it is imperative that the surgeon should be aware of which condition it is since treatment of the one by a method appropriate for the other may seriously impair the patient s chances of survival This is particularly true in infants and children

Simple water loss is observed in patients subjected to minor operative intervention accompanied by restriction of fluid intake and possibly slight sweating Such patients require the administration of fluid drinks by mouth The urinary output should be measured until at least 1 litre is produced daily The administration of saline to such patients will only exaggerate the water *deficiency since the extra sodium chloride added to their* already hypertonic extracellular fluid will be excreted in the urine a process requiring water so that the deficiency of water may be exaggerated Intravenous therapy is not indicated *unless there is an inability to swallow* in which case 5 per cent glucose in water should be given intravenously until the output is adequate The glucose introduced will be metabolized in a few hours and will provide much needed nourishment so that the net result is that the patient will have received water Repeated plasma protein estimations which may be readily performed by the specific gravity method (or repeated hæmotocrit readings if there has been no hæmorrhage) sometimes may also assist in the diagnosis and treatment of water deficiency

Primary Sodium Deficiency This occurs

(1) In any condition in which alimentary secretions are lost to the body as in vomiting diarrhœa gastric lavage or fistula

(2) Obstruction of the gut. In this condition although reabsorption is *impaired secretion of intestinal juices continue into the gut Primary* sodium deficiency is therefore found in pyloric stenosis, acute dilatation of the stomach intestinal obstruction and paralytic ileus

(3) Hypo-adrenalism This condition is very much within the province of the surgeon now that adrenalectomy is carried out for advanced carcinoma of the breast and prostate

Treatment is with 0·9 per cent saline with glucose. This should be given flavoured with lemon by mouth if possible, but usually the cause of the condition is such that this is impracticable Then the 0·9 per cent saline with glucose should be given intravenously Ideally the total loss of intestinal secretion should be measured and precisely the same amount of glucose saline given, but when the patient has lost unknown quantities of gastro-intestinal secretion either before admission to hospital or by retention in a dilated gut this may not be possible Treatment of sodium deficiency should be controlled by the estimation of the serum electrolytes—at least the plasma sodium and preferably the plasma chloride and bicarbonate as well especially when the gastro-intestinal secretions lost are highly acid or alkaline as in pyloric stenosis and biliary fistula respectively (see below) Treatment should be continued until the electrolyte content of the plasma has been restored to normal Then *if intestinal secretions* continue to be

lost they should be measured accurately and replaced by the administration of an equal quantity of 0·9 per cent. saline with glucose Once a salt loss has been corrected or is being corrected in this way the total fluid intake should be carefully balanced so that sufficient fluid is taken to replace the inevitable water loss *via* the insensible perspiration and expired air

It might be thought possible to calculate from the results of the analyses of the plasma electrolytes the amount of 0·9 per cent. sodium chloride required to restore normality but because of the elimination of sodium chloride free urine, the shift of water into the cells, the alteration in volume of the extracellular fluid is always greater than is indicated by the actual alteration in the composition of the plasma. Also a continued loss of potassium which may become significant if the loss of gastro-intestinal secretion is prolonged, may result in the intracellular fluid contributing to an unknown extent to the fluid loss Plasma analysis must be repeated after the theoretical quantity of saline has been given * Almost always, more saline is required to restore the electrolyte concentrations to normal, so that repeated plasma analyses are necessary

If there has been no recent operation it is often possible to control saline therapy by qualitative examination of the urine for chlorides Intravenous therapy with 0·9 per cent saline with glucose should be continued until chlorides appear in appreciable quantities in the urine *i.e.* until there is a flocculent precipitate of silver chloride in the usual qualitative test for urinary chlorides then if the salt loss is no longer continuing, the 0·9 per cent saline with glucose should be replaced by 0 2 per cent saline with glucose Some workers prefer to estimate the chlorides in the urine but the author is of the opinion that the qualitative test is sufficient for most purposes. However urinary chloride determinations do not always reflect the balance of chloride and sodium in the body because after surgical operations some patients with hyperchloræmia may excrete very little chloride and others with hypochloræmia may excrete much chloride. The former situation may also occur after head injuries

Mixed Water and Salt Deficiency *Unless there has been loss of gastro-intestinal secretions* water loss is usually the most marked feature after most major surgical operations Usually there has been restriction of fluid intake leading to the simple water deficiency but sweating is often excessive causing a mild degree of salt deficiency which may be exaggerated by slight post operative vomiting. This mixed salt and water deficiency is best corrected by the administration of 0 2 per cent. saline with glucose which should be administered by mouth if possible or otherwise intravenously

Table D summarizes the suggested lines of treatment for water deficiency salt deficiency and mixed salt and water deficiency

Loss of Highly Acid or Alkaline Intestinal Secretions. The alkalosis and acidosis resulting from loss of highly acid gastric juice (as in pyloric stenosis) or of alkaline bile (as with a biliary fistula) are both capable of complete

* The following example shows how the theoretical amount of saline required may be calculated.

If plasma Cl = 80 m. eq./L, extracellular fluid is only 80/100 of isotonicity (the mean normal plasma Cl = 100).

Deficiency = 20/100 = 1/5

If extracellular fluid volume (estimated as 1/5 body weight) = 12 l the required amount of normal saline = ⅕ × 12 = 2·4 l (= approx. 4 pints)

When Na and Cl are lost disproportionately the calculation should be based on the Na concentration, and the mean normal value should be taken as 140 m. equiv./l.

TABLE D

Guide to Treatment of Dehydration

	Cause	*Treatment*	*Control*
1 *Simple H_2O loss*	Simple operative procedures accompanied by sweating and restriction of fluid intake	Fluid by mouth	Measurement of urinary output till daily output adequate (at least 1 litre). Haematocrit or plasma protein estimations may help.
	Inability to swallow	5 per cent. glucose in H_2O intravenously	Ditto
2 *Mixed H_2O and sodium loss*	Operative procedures accompanied by restriction of fluid intake and sweating in theatre. Slight post operative vomiting.	Glucose lemonade in 0.2 per cent. saline *by mouth*. If such route impracticable, 5 per cent. glucose in 0.2 per cent. saline intravenously	Measure urinary output. Examine urine qualitatively for chlorides till chloride present and urinary volume adequate. In difficult cases determine plasma electrolytes as below
3 *Primary sodium deficiency*	Severe vomiting. Gastric lavage. Pyloric stenosis. Acute dilatation of stomach. Intestinal obstruction. Paralytic ileus. Severe diarrhoea. Addison's disease. Drainage of digestive juices through fistulae.	Glucose lemonade in 0.9 per cent. saline *by mouth if possible*. *If not* 5 per cent. glucose in 0.9 per cent. saline intravenously	Determine plasma sodium, chloride and bicarbonate. Repeat at 24 hourly intervals till normal and till urinary output adequate. Measure urinary output. Examine urine qualitatively for chloride.

correction by saline therapy alone and the treatment of this type of disturbance of acid base balance with acids or alkalies is positively harmful since it does not correct the fundamental abnormality which is a loss of salt. The hydrogen and chloride ions lost in acid gastric juice are derived ultimately from the extracellular fluid. The loss of chloride ions leaves an excess of sodium ions in the plasma and extracellular fluid. Similarly the loss of hydrogen ions in the gastric juice leaves an excess of hydroxyl ions which combine with carbon dioxide of which there is a sufficiency for forming bicarbonate ions. There results an excess of sodium bicarbonate in the extracellular fluid. Except in the terminal stages this excess sodium bicarbonate is excreted in the urine. Thus the net result is that chloride ions are lost in the vomit and sodium ions in the urine. In other words, the body has lost sodium chloride just as if the vomit had not been acid and had contained salt in the same concentration as in the extracellular fluid. Similarly if the body loses sodium bicarbonate *via* a biliary fistula the resulting bicarbonate deficiency in the extracellular fluid is associated with a chloride excess. These chloride ions are excreted in the urine, usually associated with an increased excretion of ammonia. Here sodium is lost in the bile and chloride in the urine and again the net loss is of sodium chloride. Such disturbances of acid-base balance are correctly treated by administration of normal saline with glucose to provide calories just as if the gastro-intestinal secretion lost consisted of extracellular fluid.

The priority of correction of electrolyte and water loss over early surgical intervention differs greatly in the individual patient. Thus a patient with pyloric stenosis may come under the surgeon s care only after many days of vomiting Unless the salt and water balance has been carefully controlled previously which is unlikely the patient will be grossly sodium deficient. The extracellular fluid volume and the plasma volume will already be seriously lowered Immediate surgical intervention would be extremely hazardous owing to the possibility of further lowering of plasma volume by hæmorrhage and shock Intravenous treatment with 0·9 per cent. saline with glucose will restore the extracellular fluid volume to normal and greatly reduce the surgical risk Unfortunately the matter is not always so simple as this. Such patients are frequently in poor condition not only on account of the sodium deficiency but also on account of what amounts to starvation While calories can be provided by the glucose administered with saline, the protein loss is less easy to correct although protein hydrolysates may prove useful If the period of pre-operative correction of salt and water balance is made too long, the protein starvation may become a major factor It is therefore sometimes necessary to operate before salt and water deficiency has been completely corrected Especially is this the case in small intestine obstruction. 0·9 per cent. saline with glucose should be given intravenously during the pre-operative period as rapidly as possible without over loading the patient s circulation. This intravenous therapy which should be continued during and after operation until the salt loss is corrected, may need to be supplemented with whole blood or plasma to correct hæmorrhage or shock. The question of treatment of shock is a difficult matter and has been dealt with elsewhere in this book It should suffice to say that treatment of shock or of hæmorrhage by plasma or blood transfusion must take precedence over the treatment of dehydration

In some circumstances, intestinal secretions may be lost *via* routes which enable the amounts concerned to be accurately measured. This is the case with drainage from a bile duct or when gastric suction is used to keep the stomach empty The volumes of fluid lost each day should be accurately measured and exactly this amount of normal saline should be given each day by mouth if this is possible but intravenously if such is not the case as with gastric lavage. The rest of the daily fluid requirements computed according to the balance sheet of Table D should be made up with 0 2 per cent saline with glucose

Salt and Water Balance in Uræmia and Oliguria

At no time is an accurate knowledge of salt and water balance more important than in oliguria whether due to hæmolysis following a mismatched transfusion, or following some operation in the region of the pelvis. Here it is essential to remember that all the time there is no vomiting, there is no loss of salt, and that although no urine is produced, there is an inevitable water loss. In temperate climates the water intake should therefore be limited to 1 litre per day plus whatever volume of urine is produced. A high-calorie, low-protein diet such as the Borst diet, consisting of a suspension of fat in glucose solution, should be given, so that the demands for excretion of nitrogenous end products are minimized. Alternatively if the patient is intolerant of this diet, the fluid intake, measured as above, should be given as a 40 per cent. glucose in an intracaval drip Such cases, conservatively

treated in this way usually respond with a spontaneous diuresis and ultimate recovery

The Artificial Kidney Apparatus has recently been developed which permits the circulating blood to be dialysed against a suitable fluid The prototypes of these "artificial kidneys" were not satisfactory but the more recent versions provide a valuable method of treatment of patients in acute renal failure when the conservative measures indicated above have proved inadequate The artificial kidney must play an important part in the treatment of the patient with oliguria and anuria in whom the serum potassium

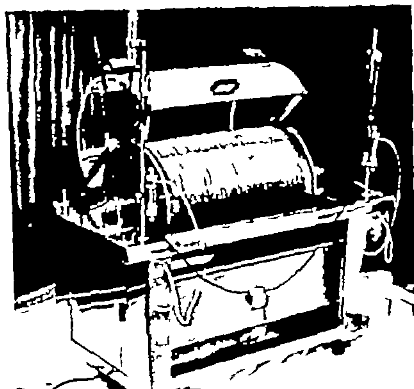


FIG. 5 1 THE ARTIFICIAL KIDNEY (*Post-Graduate Medical School, London*).

reaches a dangerous level, *e g* 9 milli-equiv./litre sooner than usual as is often the case with crushing injuries. The apparatus is also likely to be of value in other cases such as of post traumatic, post transfusion postpartum and sulphonamide-sensitivity anuria, but it is still controversial whether the apparatus should be used early in these cases or whether it should be limited to those in whom spontaneous diuresis has been delayed beyond the usual time. When such machines are available, peritoneal dialysis has no place in modern surgery but if they are not, this technique may occasionally be used in the treatment of patients with post traumatic anuria accompanied by a rapidly rising serum potassium

Potassium Deficiency

Potassium deficiency is rare and much less common than sodium deficiency not only because the total body content of potassium is greater than that of sodium but also the gastro-intestinal secretions as a whole contain much less potassium than sodium. Potassium deficiency of sufficient

Chapter 6

BLOOD TRANSFUSION

The Blood Groups

In addition to the common methods of subdividing the human race into groups according to language differences, colour of skin and other physical features, there is another perhaps even more fundamental method based on inherited antigenic differences, of which the blood groups are the best recognized examples.

The protein stroma of the human red blood corpuscles has far from a standardized structure and in fact it may well be that every person's blood is as individual as his fingerprints. Many of these structural differences

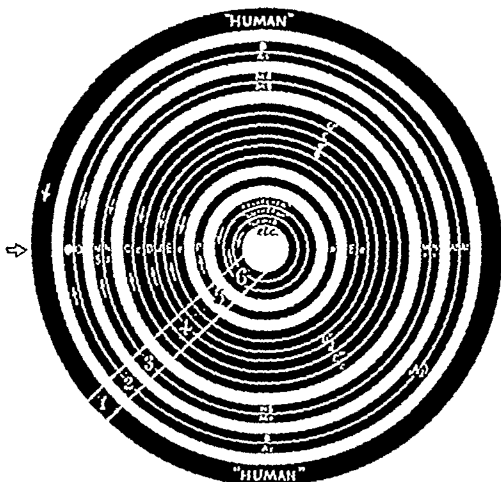


FIG. 6 1 THE ANTIGENIC STRUCTURE OF THE CORPUSCLES.
By rotating the rings independently the possible combinations can be formed in line with the arrow

are of serological importance, that is, they are capable of reacting with the specific antibodies, and of evoking the formation of such antibodies in suitable circumstances

It can be seen from the diagram (Fig. 6 1 *ring* 1) that the most powerful antigen, the "human antigen is common to all and distinguishes human blood from that of other animals. Second to this come the antigens for the *ABO* system (Fig. 6.1 *ring* 2) which divide human beings into four main categories.

The ABO System. This is peculiar in that the differences are not confined to the corpuscles, but include related antibodies in the serum The antigenic substances are called A, B and O and the groups are named according to whether there is A, B AB, or O in the corpuscles. The antibodies present naturally in the serum are anti A and anti B and correspond to the antigen or antigens missing from the corpuscles. That is to say if the cells contain group O substance there will be both anti-A and anti B in the serum if group A substance, anti B if B anti A if AB there will be neither (see Table A).

To group blood in the ABO system drops of a 2 per cent suspension of the cells is mixed with drops of anti-A and anti B sera either on a white tile or in tubes, and as a cross check drops of the serum are tested against known A and B cells. Agglutination develops in 10 to 30 minutes at room temperature (Fig. 6.2).

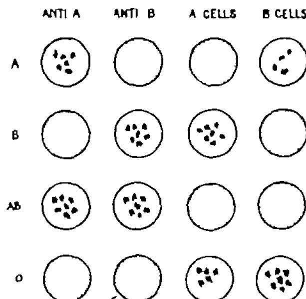


FIG. 6 2. THE ABO BLOOD GROUPS.

Reading horizontally the cells from the four main ABO groups have been tested against the grouping sera anti-A and anti-B and the sera from the same bloods against known group A and group B cells. Agglutination is distinguished from the evenly distributed cells where no reaction has occurred.

These group specific antigens and antibodies are inherited according to the Mendelian laws and the controlling genes may be present in one or both of the pair of determining chromosomes A and B are equal but dominant to O thus the four groups have the genotypes OO AA or AO OB or BB and AB (Fig. 6.3)

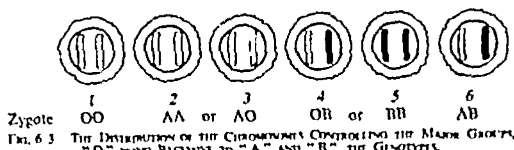


FIG. 6.3 THE DISTRIBUTION OF THE CHROMOSOMES CONTROLLING THE MAJOR GROUPS, "O" BEING RECESSIVE TO "A" AND "B" THE GENOTYPES.

Although the distribution varies in different parts of the world in this country groups A and O are nearly equally represented and are found in just under 90 per cent of the population group B around 7 per cent and group AB in another 3 per cent In Fig. 6 3 the pairs of chromosomes involved in the ABO groups are shown for the purpose of indicating that both the heterozygous and the homozygous states are possible in groups A and B

From Table A which shows the effects of mixing the cells and sera from the various groups it can be seen that group O cells are not agglutinated by any ABO serum. At the same time the antibodies in a donor s serum unless abnormally powerful need not be taken into consideration for on injection they are immediately neutralized by the not inconsiderable quantity of antigenic substance in the recipient s serum and any excess is so dissipated amongst the twenty five billion circulating corpuscles as to be harmless. The consequence is that group O blood can be given to anyone in an emergency *and group O individuals are therefore known as universal donors*

TABLE A

BLOOD GROUP		O	A	B	AB	
	Cells contain	O	A	B	AB	antigens
	Serum contains					
O	Anti A, Anti-B	—	+	+	+	
A	Anti-B	—	—	+	+	
B	Anti A	—	+	—	+	
AB	—	—	—	—	—	
	antibodies.					

Agglutination = +

It is not good practice, however to use group O blood indiscriminately for although the chance of an individual of another group developing anti-O substances following such a transfusion is too slight to require consideration, the real difficulty is that the supply will not meet the demand. A *part of the donor panel would be supplying blood for the majority of transfusions* and this arrangement already liable to fail, becomes impossible when the Rhesus factor is taken into consideration.

Occasionally a "dangerous universal donor" is found in whose blood the anti A or anti B antibodies are sufficiently powerful to destroy the recipients cells. For a similar reason the large amount of antibody introduced is dangerous when a massive group O transfusion is given to a recipient of another group

Another difficulty may arise from the subdivision of group A into A_1 and A_2. Thus group A represents the genotypes A_1A_1 A_1O A_1A_2, A_2A_2 and A_2O and group AB A_1B and A_2B with A_1 roughly three times as frequent as A_2. An A_2A_2, A_2O or A_2B recipient may have anti A_1 antibodies but fortunately they are rarely of significance for they are usually very weak and not active at body temperature.

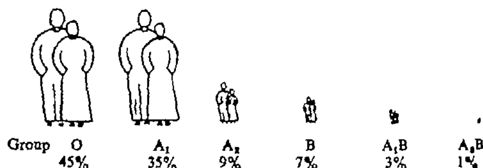


FIG. 6 4 THE DISTRIBUTION OF THE BLOOD GROUPS AS A PERCENTAGE OF THE POPULATION.

It can also be seen from the table that any type of corpuscle may be given to an AB individual, but again it is probably better to give the correct group if possible The effects of transfusions of wrong blood are discussed on page 118

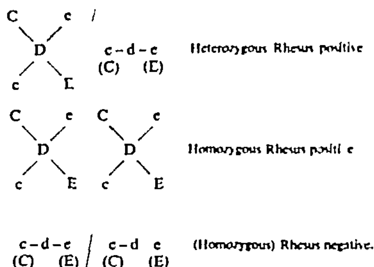
Rhesus System. This is next in importance to the ABO grouping (Fig. 6 1 *ring* 4) Here the serological differences forming the system are more complex, involving three major pairs of antigens, determined by a similar number of genes. These are known as C c D d, and E e the large letters denoting the dominant alleles The presence of D means Rhesus positive and where both members of the pair of chromosomes bear D the individual is called homozygous Rhesus positive for all the spermatozoa or ova will carry the D gene, but when one chromosome has the D gene and the other d then the individual is heterozygous and alternate spermatozoa or ova are Rhesus positive and Rhesus negative. All Rhesus negative persons must be homozygous with the genetic structure d d

It is usual for transfusion purposes to group the blood as Rhesus positive or negative. This is done by incubating in a tube at 37° C. for two hours, a drop of 2 per cent. suspension of the cells and a drop of a known anti D serum. The cells are then examined under the microscope for agglutination after spreading them very gently on a slide

The associated genes C c, and E e although of lesser importance may on occasion produce antibody reactions, but apart from this, the frequency of the various combinations of these genes has at present an important practical application, for it provides the only laboratory method for determining if a Rhesus positive individual is homozygous or heterozygous. Anti-d serum is not available so that the only possible method of determining whether the second chromosome contains D or d is an indirect one

By testing the cells with the four available sera anti C, anti-c anti D and anti E and correlating the results with the frequencies of the chromosomal patterns which have been worked out from heredity studies it is possible to come very close to the correct answer For example the commonest homozygous combination is CDe/CDe and the commonest heterozygous is CDe cde and the alternatives which would give the same agglutinations and yet be heterozygous and homozygous respectively are the much less frequent combinations CDe/Cde and CDe cDe There is roughly a 5 per cent chance of such an error in the method

The diagram below shows the chromosomal distribution of D and d in the heterozygous and homozygous types and roughly indicates by the upper letter being more common than the lower the major frequencies of the associated genes C c and E e



c – d – e / c – d e (Homozygous) Rhesus negative.
(C) (E) / (C) (E)

Thus the combination CDe/cde (35 per cent.) is more frequent than cDE/cde (14 per cent.) and CDe/CDe (18 5 per cent.) than CDe/cDE (13 per cent.) while with d c and e are so much more frequent than C or E that cde/cde (15 per cent.) is much commoner than cdE/cde (0·9 per cent.) or Cde/cde (0 8 per cent.).

It is common to use a simplified notation in which R denotes a dominant and signs indicate the other genes present In this system

R_1 = CDe.	R_0 = cDe	R = Cde	R_z = CDE.
R_2 = cDE.	r = cde.	R = cdE.	R_y = CdE.

Fig. 6.5 gives more detail of the distribution of the Rhesus factors and the corresponding chromosomal structures.

In the serum there are no natural antibodies corresponding to the Rhesus antigens, but immune antibodies can be developed. This difference between the ABO and the Rhesus systems is of considerable significance for while in the former the antibodies are there already awaiting to agglutinate and destroy any mismatched corpuscles which are transfused, the Rhesus anti bodies are only created as a response to the introduction of the Rhesus antigen usually through giving Rhesus positive blood to a Rhesus negative individual or from a transplacental leakage, when a Rhesus negative mother

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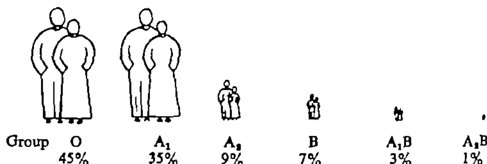


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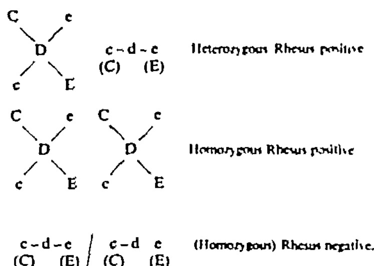
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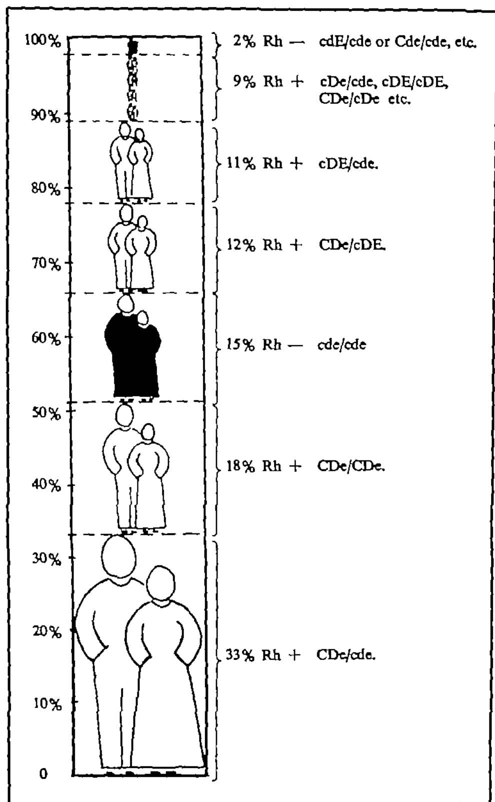


FIG. 6 5 THE DISTRIBUTION OF THE GENOTYPES IN THE POPULATION.

is carrying a Rhesus positive child Once formed the immune antibodies are ready to agglutinate any further Rhesus positive blood introduced

Although this is the usual reaction the various other Rhesus antigens may be involved so that less frequently Rhesus positive individuals are found to have antibodies

This difference between the two systems goes further for while the natural ABO antibodies are more active at room temperature than at body temperature the opposite applies to the immune antibodies of the Rhesus system and as a result the simple cross matching techniques carried out on a white tile usually misses them

Natural ABO antibodies too are of the complete type that is to say saline dilutions of the sera agglutinate saline suspensions of the appropriate corpuscles but some and this applies frequently to the Rhesus antibodies are of the incomplete variety and fail to agglutinate cells in saline They are active however within the body and their detection *in vitro* requires special methods Thus it can be shown that if the corresponding corpuscles are incubated with the serum containing the incomplete antibodies, these are adsorbed and the corpuscles are altered so that (*a*) they can no longer be agglutinated by known complete antibodies (the blocking test) but (*b*) can be induced to agglutinate in the presence of colloidal solutions particularly serum or 20 per cent bovine albumin (the albumin test) or (c) if freed from all serum by washing can now be agglutinated by an anti human globulin serum prepared in a rabbit (indirect Coombs's test) on account of the adherent antibodies being globulins Alternatively the corpuscles may be "sensitized" so as to react with these antibodies by treatment with trypsin or papain before incubation with the serum

Cross Matching. It is necessary to match the donor with the recipient both in regard to the ABO and Rhesus systems, but even this is not com

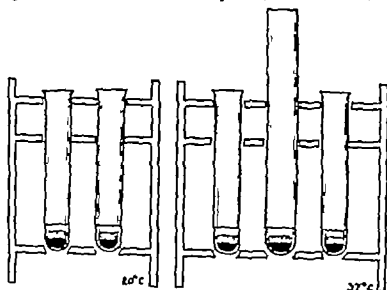


FIG 6 6. THE "COMPLETE METHOD" OF CROSS MATCHING.

prehensive and there are other factors which although rare may be of significance. These include other systems and certain subgroups not allowed for in the normal ABO and Rhesus groupings, but they and any technical or clerical errors can be detected in the individual case by the "complete

method " of cross matching. This method however is not available for emergency work as it takes about three hours to apply and various modifications with decreasing degrees of safety have to be used.

In the complete method five tubes are used two in one rack and three in another (Fig. 6 6) Into each tube are placed two drops of the recipient s serum and two drops of a 2 per cent. suspension of the donor s washed corpuscles. To tubes 1 2 3 and 4 are added two drops of saline and to tube 5 two drops of bovine albumin Tubes 1 and 2 are left at room temperature (20° C.) and tubes 3 4 and 5 are incubated at 37° C. At the end of one hour the first tubes are read. Agglutination in tube 1 shows that either natural or cold antibodies (agglutinins) are present and tube 2 is then incubated for half an hour If it is a cold agglutinin, the clumping disappears on heating but reappears on cooling again

Corpuscles sensitive to the natural agglutinins in the recipient s serum are a great danger and on no account should they be used for a transfusion. Cold agglutinins are of no significance although it is customary to ensure that the blood is brought to near body temperature, but certainly never any higher before being transfused.

If tube 1 is negative, or the agglutination proves to be only cold agglutination tubes 3 and 5 are read at the end of two hours incubation Complete antibodies of the immune type show in both but incomplete are only detected in tube 5 The agglutinates, particularly the anti Rhesus agglutinates found in these tubes are less robust than those of the ABO system and the cell deposit must be taken gently from the tube with a Pasteur pipette spread on a slide by a dragging motion and examined under a microscope

The reading of these tubes requires some practice for trivial degrees of pseudo-agglutination or even quite coarse clumping from rouleaux formation complicate the picture. Uniformly distributed clumps of four or more cells cannot be disregarded and the blood should not be used.

Tube number 4 which is of a larger size (100 x 8 mm.) to facilitate washing the cells and may with advantage contain larger quantities of the reagents, is kept for confirmation. If there is still doubt particularly regarding rouleaux formation in the albumin tube, or a history suggesting that the recipient may be sensitized, the cells in this tube are washed in saline several times and mixed on a slide with a drop of a suitably diluted antihuman globulin (Coombs s) serum. If there is no agglutination at the end of ten to fifteen minutes the test is negative

Any important agglutination will be detected by this complete method " but there still may be slight doubt about one of very low titre. In such a case if blood is absolutely necessary a trial transfusion of some 50 to 100 ml may be given the patient watched for symptoms and his blood examined at the end of one hour for any rise in the bilirubin level indicating hæmolysis If the patient takes this blood without difficulty the remainder may be given by a slow drip although a careful watch should be kept for any untoward signs.

Unfortunately as already stated, the complete method takes too long to be available for emergencies, and although the number of emergencies can be decreased by determining the patient s ABO and Rhesus groups before any serious operation and having blood ready there will always be the unanticipated cases.

Thus degrees of safety must be considered In a dire emergency it is justifiable to give blood of the same group if this is known or of group O (Rhesus negative if possible and certainly to women below the age of the menopause) without cross matching Where there is only the minimum amount of time available a simple tile cross matching of the donor s corpuscles against the patient s serum will exclude gross ABO incompatibility and eliminate practically all the risk in connection with a first transfusion except perhaps in women *who have had an erythroblastotic child* In all other cases the complete method should be used

Of the other antigen antibody systems the " Kell " and " Duffy are the most important and have given rise to serious reactions Antibodies in these systems are detected non specifically by the complete method of cross matching, particularly by the antihuman globulin (Coombs s) technique and can be isolated using a panel of donor cells of known antigenic structure

Although all persons who have had a transfusion or a pregnancy are liable to carry abnormal antibodies, the formation of these is completely irregular In some individuals antibodies are demonstrable within a week of a transfusion of cells containing an antigen foreign to them while in others little change can be found even after several transfusions of blood of a similar degree of incompatibility A comparable state exists with regard to pregnancies, where the child and the mother are of different blood groups. Even when all the conditions necessary to produce antibodies appear to be present (*i.e* a Rhesus negative woman carrying a Rhesus positive child) the chances of antibody formation are only 1 in 20

From the practical point of view Rhesus negative persons are more likely to have antibodies than Rhesus positive and people who have had previous transfusions and women who have had children with erythroblastosis should be considered with special care. In grave emergencies they must be given either of their own group or group O Rhesus negative blood but the complete cross matching should be set up and continued even if the blood is being given for if a gross incompatibility is encountered it may not be too late to stop the transfusion or at least the appropriate treatment can be put into operation without delay

Finally in a planned transfusion it is not justifiable to take any risk that can be avoided either of an immediate reaction or of the laying up of trouble for subsequent transfusions or pregnancies.

A point of considerable importance is that the blood to be given should be cross matched with the patient s serum taken at the time and particularly not that taken before the first transfusion. With a patient receiving repeated transfusions the serum should be " up to date," that is to say never more than five days old, to exclude the chance of early antibody formation

When a sample of blood is to be taken from a bottle for cross matching, the bottle should only be kept out of the refrigerator for the minimum amount of time necessary to take a sample by means of a dry sterile syringe inserted through the rubber of the cap Bottles left out of the refrigerator particularly those kept in a warm theatre for an hour or two and then not used, cannot be returned to the bank and have to be discarded.

On the other hand, even out-of-date blood if it has been properly stored is still of use for the plasma can be converted into various blood products which are in increasing demand, including dried plasma, fibrinogen, fibrin foam and thrombin.

As an alternative to the straightforward giving of whole blood, it is sometimes an advantage to remove most of the plasma from the blood and use the "packed corpuscles" for transfusion. In this way it is possible to give the patient the maximum amount of extra oxygen carrying power with the minimum increase in the blood volume.

The Technique of Blood Transfusion

Although the present common practice of using stored blood from a blood bank for nearly all transfusions has made the operation very easy and almost completely impersonal it must never be forgotten that each bottle of blood is taken from a voluntary donor and that to use it withou due consideration is to abuse his generosity

Taking Blood. The blood is drawn from the donor's vein into a M R.C pattern bottle, using sterile precautions. In the bottle there is rather over 100 ml of an anticoagulant mixture containing acid-citrate and dextrose, the former to prevent coagulation and to help with the dextrose to preserve the corpuscles The blood is stored at rest in a refrigerator at just above freezing point (+ 4 C.) at which temperature the chance of growth of accidental contaminants is much reduced the development of natural hæmolysins is delayed and yet the damage to the corpuscles caused by freezing is avoided. The blood can be used up to three weeks (or in an emergency even a month) after it has been taken All blood bottles are marked with the ABO and Rhesus groups, have a number which should be recorded in the recipient's notes so that the donor can be traced (see under transfusion reactions) and are dated.

Occasionally it is an advantage to use fresh blood and this is drawn from a healthy donor and given at once to the patient. For simplicity in description it is to be assumed that the transfusion is to be of this type but the bleeding of blood bank donors is done in the same way

First of all unless there is extreme urgency as has already been discussed the patient's blood group has to be determined and a suitable donor of the same group discovered. About 5 ml of the patient's blood is taken into a dry tube and this may be encouraged to clot and extrude serum by placing it in an incubator for a quarter to half an hour The clot may have to be freed from the sides of the bottle. If necessary the separation of the serum can be accelerated by spinning the bottle with the clotted blood in a centrifuge. The serum is then put aside for cross matching and some of the corpuscles from the clot are washed three times in saline. This is done by repeatedly resuspending them in fresh quantities of saline after spinning down in a centrifuge.

The corpuscles are then grouped and a donor of the same group is selected must be healthy and in particular free from syphilis, malaria, asthma, caria and not have had jaundice, at least within the last five years. s also important to notice that the donor has reasonably well developed ns, for the blood must be taken through a large bore needle to avoid otting and "cutting down" is not normally permissible. Finally a few ops of the donor's blood from an ear puncture are taken into a tube con ining saline the corpuscles are then washed and matched against the ecipient's serum This is a most important precaution for it is the final est of compatibility and if the time permits, it should be done with the full precautions already discussed.

When a compatible donor has been found an adequate quantity of blood usually about 400 ml is withdrawn in the following manner

The donor is made to lie down in a well lighted room and care is devoted to choosing and distending a suitable vein Usually one on the outer side of the antecubital fossa is selected and a sphygmomanometer band placed above the elbow is adjusted to find the pressure which gives the maximum distension It is an advantage to put the rubber connections to the band on the upper side to be out of the way and the best dilatation of the veins is normally obtained at just above the diastolic pressure



FIG. 6 7 APPARATUS FOR THE TAKING OF BLOOD FOR A BLOOD TRANSFUSION.

A towel is placed below the donor s arm The operator cleanses his own hands and then prepares the skin surface about the site from which the blood is to be taken with a suitable antiseptic such as a weak solution of iodine in spirit. An assistant raises the sphygmomanometer pressure while a very small amount of 2 per cent. procaine or other local analgesic is injected into the skin and subcutaneous tissues over the vein at a point just above the fold of the elbow The quantity used must be small or it will obscure the outlines of the vein. A short time should be allowed for the local analgesic to act, during which the sterile apparatus for taking the blood is assembled

This apparatus illustrated in the figure comprises a rubber tube about 2 feet in length, with wide bored needles at either end an air outlet consisting of a needle attached to a wool packed glass filter by a short piece of rubber

tubing and a blood collecting bottle. The needles, which are protected and kept sterile by glass tubes are for insertion into the vein and through the rubber cap of the top of the collecting bottle. The collecting bottle is of the usual waisted M R.C. type it contains some 120 ml of the dextrose citrate solution and is closed by a rubber-lined metal cap provided with two holes. One of the holes is for the needle on the lower end of the " taking tube," the other for the needle of the air outlet filter

When all is ready the sphygmomanometer pressure is again raised by the assistant and the protective sterile coverings are taken from the top of the collecting bottle, which is now placed on a stool so as to be a little lower than the level of the elbow The operator gives the lower end of the " taking tube " to the assistant, who withdraws the needle from the glass tube and pushes it through one of the openings in the top of the collecting bottle. The needle of an air outlet filter is pushed through the other opening. When this has been carried out the operator removes the protecting glass tube and the stylet from the vein needle. He puts his left hand behind the donor's elbow partly to keep it straight and partly by a grasping movement to make the skin taut. He then plunges the needle directly through the anæsthetized area of the skin into the vein.

The care which has been taken in the preliminary choice and adjustment is usually well repaid and after a moment blood will pour down in a steady stream into the anticoagulant fluid. The bottle is allowed to fill to the " 500 ml. mark care being taken to keep the blood agitated to insure that it mixes with the anticoagulant solution.

It is better not to attempt to fix the needle in the vein during this short operation, but simply to hold it steady If the blood slows down a very slight movement of the needle to relieve pressure on the distal part of the vein or getting the donor to open and close his hand very gently is usually sufficient to increase the rate again.

When the mark is reached, the sphygmomanometer pressure is lowered the armband freed, the needle quickly withdrawn from the vein and, using a sterile swab firm pressure is applied to the needle hole for some two to three minutes to stop oozing or the formation of a hæmatoma When the blood has drained out of the taking tube, the two needles are pulled out of the cap of the bottle the blood is shaken gently and is then ready for giving. It only remains to be sure that the donor is comfortable. He should be given a warm drink and kept lying for about half an hour but thereafter if the medical officer is satisfied that he shows no ill effects he should be allowed to go The removal of one pint of blood has usually relatively little effect on a healthy individual but it is careless as well as ungracious not to think of the donor's reactions.

Giving Blood. As with the donor the patient must be in a good light and, using the sphygmomanometer to the best advantage, a suitable vein is again chosen Here it may be necessary " to cut down on a vein but the decision to do this should only be made when a thorough inspection has shown that the state of collapse is such that the veins cannot be distended sufficiently to allow a needle to be used or where a determined attempt has failed If the veins can be felt but not seen it is well to raise and lower the sphygmomanometer pressure once or twice so as to be certain that the structure palpated is in fact, a vein, which distends and empties and not for example, a tendon

The easiest site for giving the blood rapidly is in the antecubital fossa, but

for the slower drip transfusions a vein on the front of the forearm shortly above the wrist or on the leg just above the ankle should be chosen for these regions can be controlled easily by a splint to prevent movements which would pull the needle out of the vein The sphygmomanometer band is then adjusted proximal to the chosen vein

When the operator has cleansed his hands and the patient's skin he covers the patient's forearm with a sterile towel While he assembles the sterile giving apparatus his assistant adjusts the stand for the blood bottle The giving apparatus (Fig 6 8) consists of a needle of rather smaller bore

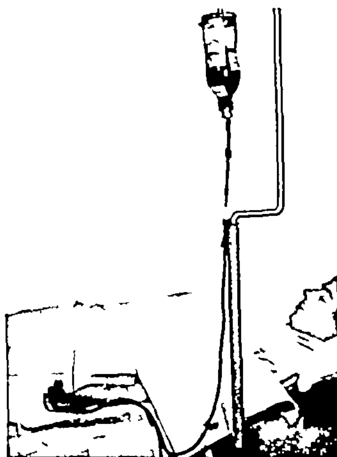


FIG. 6 8 APPARATUS FOR GIVING A BLOOD TRANSFUSION.

than the taking needles, which is again protected by a glass tube and attached by a short rubber tube to the "socket" part of a metal connecting piece. The "plug" portion of the connecting piece is attached to the filtering apparatus, for insertion into the blood bottle, by a long rubber tube. In this rubber tube there is a glass "drip tube" which serves both to indicate the speed of the blood flow and to trap any air bubbles. A screw clip surrounds the tube near the connecting piece. The filtering apparatus is mounted on a tapered rubber bung and consists of two glass tubes and a woven "gas mantle." The longer tube which goes down through the bung to the bottom of the bottle acts as an air inlet and supports one end of the net filter mantle, the other end of which is fastened around the narrower

part of the rubber bung. The shorter tube for the outflow of blood opens inside the mantle so that no clots can pass out of the bottle.

When all the apparatus has been freed of its sterile wrappings, the metal cap of the blood bottle is replaced by the filtering apparatus and the bottle is hung upside down on the stand at a height of about 3 to 4 feet (1 metre) above the patient's arm. *The pressure clip on the rubber tubing is slackened* and the blood is allowed to flow down to fill the tube and to squirt momentarily from the connecting piece. The pressure clip is then tightened and the assistant holds the tube at a point a little below the drip tube and keeps the connecting piece from coming into contact with anything not sterile. The blood is now ready to give.

The sphygmomanometer pressure is once more adjusted, the needle is taken from its protecting glass tube and plunged through the skin into the vein. If this is successful, blood starts to flow back through the needle and as soon as this happens the connecting pieces are joined together and the sphygmomanometer pressure is removed.

The screw clip is again released and when a free flow of blood into the vein is established, the needle is covered with a sterile swab and fixed in position by two pieces of adhesive plaster. Often it is advisable to loop the tube between the thumb and the first finger and fix it in front and behind the arm with adhesive plaster. The arm or the leg is then bandaged to a padded splint to prevent movements.

Finally the flow of the blood is adjusted to the rate at which it is desired to give the transfusion, the speed being judged by the rate at which drops fall inside the drip tube. Usually about 50 drops to the minute is a suitable speed and means that a 500-ml. bottle will last about three hours, but the rate of flow varies a little with each apparatus. The average drip tube delivers some 20 drops of blood or 25 drops of saline per ml. (see Table B).

TABLE B

Rate of Blood Flow in Transfusion

Drops per minute	*ml per hour*	*M.R.C. bottle of blood in hours*
20	60	8
40	120	4
60	180	3
80	240	2
100	300	1½

The apparatus just described is now being replaced by apparatus using plastic tubing and a plastic filter and drip chamber. This differs a little in the method of assembly in that instead of removing the top from the bottle a double needle, with one lumen for blood and the other for an air vent, is

inserted through the rubber cap. Sometimes a plastic bag replaces the blood bottle.

After acute blood loss the blood can be given at a much faster rate. In fact if given *almost at once* it can be run in as rapidly as it will flow, but if time has elapsed and the circulatory volume has been partly replaced the speed must be tempered to the degree of correction. Where there is any evidence of heart failure, acute toxæmia from infection or severe chronic anæmia the rate must be very carefully watched so that the heart is not embarrassed by a sudden increase in the circulating blood volume.

If the operation of inserting the needle into the vein has not been successful, the blood may flow into the tissues and cause a hæmatoma. The blood flow should be stopped at once and the needle reinserted, possibly in the other arm.

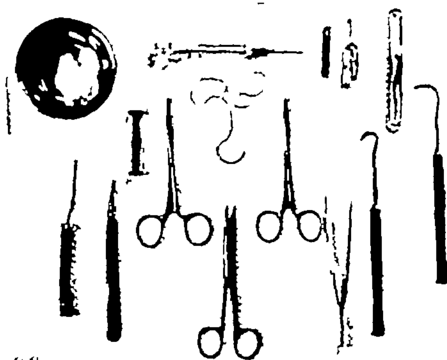


FIG. 6.9. THE INSTRUMENTS FOR "CUTTING DOWN."

Gallipot with spirit and swabs. Syringe and needle. Ampoule of procaine hydrochloride 2 per cent. solution. File. Tube of catgut.

Spool of cotton thread. Two artery forceps. Cutting needle. Aneurysm needle.

Intravenous cannula. Scalpel. Scissors. Dissecting forceps. Blunt hook.

Cutting Down. When no suitable veins are available, particularly in shock where the vessels are collapsed, it will be necessary to "cut down." The materials required for this (Fig. 6.9) are sterile towels and swabs, a 2 ml. syringe and needles, 2 per cent. procaine or other local analgesic solution, spirit or some other suitable skin disinfectant, a scalpel, two artery forceps, one fine dissecting and one rat-toothed forceps, one aneurysm needle, fine catgut, one intravenous cannula with rubber tubing to connect it to the giving apparatus, a sharp-pointed scissors, one curved cutting needle and suture material for the skin, and a sterile dressing.

When the skin usually either of the forearm or about the ankle, has been cleaned, a small amount of local analgesic is injected to infiltrate an area of about 3 cm in diameter After a suitable interval a short transverse incision about 2 cm. in length is made and a vein of sufficient size to admit the cannula is located in the subcutaneous tissue. With the aid of the aneurysm needle the vein is freed and two catgut ligatures are passed around it. The distal one is pulled tight and tied while the proximal one is left as a single loop *With the scissors a small oblique snip is made in the vein* between the ligatures and the cannula, previously connected to the giving apparatus and filled with blood is inserted into the vein and held in position by tightening the proximal ligature with the formation of a bow The skin edges are then drawn together with one or two sutures and the wound is covered by the sterile dressing.

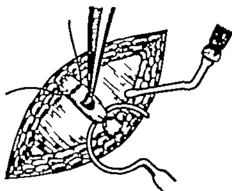


Fig 6 10. "Cutting Down."

When the blood is flowing freely at the desired rate, by any of the methods described the patient can safely be left although frequent visits—say at fifteen minute intervals—are necessary to see that the rate of flow is constant and that no undesirable reactions are developing. When the transfusion is finished the needle is withdrawn and after pressure with a sterile swab for a few minutes a light dressing can be applied Where it has been necessary to cut down the process is rather less simple, the area must be cleaned the wound reopened, the upper ligature tied, the vein divided between the ligatures to avoid the risk of hæmorrhage from a wounded vessel the skin sutured and a dressing applied.

Intra-osseus Transfusion For various reasons the use of the veins suggested may not be practicable, for example in infants or where there is severe burning. In infants, the scalp veins the superior longitudinal sinus, and the internal jugular veins may be used, while both in infants and in adults it may be an advantage to give fluids into the medullary canals of the bones. In infants, the tibia may be used, but after four years of age, when the cortex becomes too hard and the red vascular marrow recedes from this bone, the sternum becomes the site of choice. For the administration of blood by the intra-osseus route a special needle (M.R.C pattern) with wings to allow it to be fastened to the skin by adhesive plaster is often used. The site of choice is the upper part of the body of the sternum opposite the second intercostal space, but the manubrium may be used.

After cleaning the skin a 2 ml syringe filled with 2 per cent lignocaine or other powerful local analgesic is used to form a small skin bleb over the chosen site The needle is then pressed forward and the subcutaneous tissue down to the periosteum is anæsthetized A short interval should be allowed for the analgesic to act before the needle is pushed through the periosteum at several points and an attempt made to anæsthetize a small circular area

It is preferable to incise the skin with a small "ophthalmic" scalpel as there is then no tug on the giving needle and less risk of infection or the forming of an implantation cyst. The needle is inserted through the incision and pushed down to the bone The periosteum if properly anæsthetized should not be tender and the needle can be gently but firmly pressed forward with a rotating movement into the cortex of the bone Here unless the bone is abnormal it will be firmly gripped but as the cortex is penetrated the resistance suddenly diminishes and the needle can be advanced without difficulty in the medullary cavity It should not be pushed more than about 2 mm. into the marrow The stylet is then withdrawn and the giving set is connected as soon as it is certain that the marrow cavity has been reached Usually the blood runs slowly for the first five or ten minutes and then if all is well, the regular flow becomes established and can be maintained for a long period There is, however considerable risk of osteomyelitis and a slight risk of fat embolism and the method should only be used when no other route is available.

Intra-arterial Transfusion Occasionally in very severe shock or after a massive hæmorrhage when either an intravenous transfusion would not flow or would be too slow to be of value it may be possible to restore the circulation by an intra arterial transfusion under pressure. The immediate danger of such a transfusion is air embolism and an air locking float chamber must be included in the circuit. The blood may be given either into a peripheral artery or into the aorta. The radial or ulnar arteries may be sacrificed for this purpose but there is often severe arterial spasm impeding the blood flow during the transfusion or later interfering with the alternative blood flow through the palmar arch and even leading to gangrene. If the abdominal or thoracic cavities are open at the time of the emergency the needle of the intra arterial giving set may be inserted directly into the aorta At other times a special needle, with a step about 1 cm behind the point, can be inserted through the lumbar muscles The skin is pierced at a point a handbreadth to the left of the middle line level with the third lumbar vertebra. The needle is pushed forward and inward to touch the body of the vertebra. The point is then moved across anteriorly to touch the aorta When the pulsation is felt the needle is thrust forward again until the point up to the step enters the aorta. By intra-aortic transfusion a litre of blood can be given in under five minutes but there is the danger of hyperpotassiumæmia and hypocalcæmia. The pressure necessary to force the blood into the circulation can be supplied, either by pumping air into the blood bottle by means of a sphygmomanometer bulb or by means of a mechanical pump usually working on the principle that a cam squeezes the blood round a loop of the rubber tubing.

Massive Transfusions These include the large transfusions given to combat shock from extensive blood loss, the exchange transfusions given in the neonatal period in the treatment of erythroblastosis fœtalis or rarely in adults, particularly in leukæmia and the use of the "artificial kidney" and

the "heart-lung apparatus" in which the blood circulates through an extracorporeal machine

In these in addition to the difficulties of avoiding overloading the circulation, air embolism and weak antibodies reaching significant total quantities, the danger of new biochemical upsets arises. In health a considerable quantity of citrate can be metabolized rapidly or excreted in the urine, but there is a limit to this process and in massive transfusions the total quantity of citrate is large Particularly if there is hepatic or renal disease or the metabolism is reduced by barbiturate anæsthesia or hypothermia the citrate will reduce the effective or ionized serum calcium to dangerous levels and act directly as a depressant on the cardiac muscle

Other anticoagulants have been used. Heparin is non-toxic if expensive, but *only inhibits fibrin formation for a time. The exchange resin ethylene* diamine-tetra-acetic acid (Sequestrine) has up to the present a limited value, for only 1 g. per 14 Kg. body weight may be allowed to enter the blood stream in twenty four hours.

Reactions to Transfusions

It must be stressed that no transfusion of blood should be undertaken lightly for there are possible risks which may be disagreeable undesirable and even lethal In each case the benefits anticipated should be weighed against the value of the blood as a rare commodity and the risks, even if they are slight of the immediate reactions, the more delayed infective processes, and *the immunological complications.*

Thus when faced with a life-endangering hæmorrhage blood should be given without further thought but when it is only that a patient is recovering slowly a more conservative view should be taken and if it is decided to transfuse, this should be done deliberately after cross matching has been carried out with meticulous care.

The immediate reactions to transfusions can be divided into three groups (1) Those due to substances introduced along with the blood (2) those due to a bad response on the part of the patient to an increase in the circulating blood volume and (3) those due to certain incompatibilities between the donor's and the patient's blood and tissues.

(1) Foreign Substances This includes the simple febrile reaction which is usually more alarming than serious. It is due to the introduction along with the blood of pyrogenic substances, dead bacteria, protein breakdown products, particularly from old blood left in the transfusion apparatus, and simple chemicals such as sulphur from new rubber tubing. These reactions can be avoided in the main by scrupulous cleanliness, as well as sterility of the apparatus and solutions used.

Such reactions come on suddenly perhaps even with a rigor the temperature rises rapidly and the patient may complain of thirst coldness, and headache. The treatment is by keeping the patient warm with hot water bottles and extra blankets, while if given early 10 ml. of a 10 per cent. solution of calcium gluconate may stop the chill After such a reaction all the apparatus and solutions must be changed before continuing the transfusion.

The reactions due to giving quantities of blood which has hæmolysed from age or overheating, or blood which is definitely infected are often more serious and may be fatal. To avoid such reactions the blood must be properly handled at all times, with extreme care exercised in the prepara

tion of the blood bottles and other apparatus and in the actual taking of the blood During its storage the blood should be kept constantly at +4 C never allowed to freeze and never shaken while blood over three weeks old should not be used Before use each bottle must be inspected for any sign of hæmolysis which indicates either bad storage or definite infection of the blood but it must be remembered that such examination is not infallible for certain contaminating organisms can grow in stored blood even at refrigerator temperature and yet cause no hæmolysis

Rather more rarely the blood from certain individuals may contain substances which in sensitive patients cause allergic reactions such as urticarial rashes, eosinophilia localized œdema joint and glandular swellings and possibly even asthma Persons who suffer from any well-defined allergic condition should not be used as donors and patients known to suffer from asthma hay fever urticaria angioneurotic œdema etc who are receiving a blood transfusion should be watched for such reactions Adrenaline (0 1 to 0 5 ml of 1 1000 solution of adrenaline subcutaneously) is probably sufficient to stop such a reaction but it may be necessary to consider desensitization or antihistamine drugs particularly if a second transfusion is necessary after a reaction A suitable antihistamine is chlorphenisamine maleolate (Piriton) used as 10 mg. in 500 ml. of blood The effect lasts six hours and the maximum dose is 40 mg. in twenty four hours.

(2) *Volume Transfused* Increased circulatory volume is of particular importance in patients with pneumonia or any myocardial weakness, including those who have had severe anæmia for some time but even the fittest recipient will succumb to gross overloading of the circulation.

The myocardium or the vessel walls weakened from degeneration toxæmia or anæmia respond poorly to the increased blood volume and cardiac failure is likely to develop particularly if the blood is given too quickly Such a breakdown may result in either acute pulmonary œdema with dyspnœa, cough cyanosis, and precordial pain, or a peripheral circulatory failure with the signs of shock, and death can occur from either of these causes.

If the danger is realized such reactions can be avoided, at least almost always, by limiting the transfusion to 1 000 ml. in twenty-four hours, in cases where there is danger repeating this if necessary after an interval. The use of packed corpuscles avoids some of the difficulties, by limiting the total volume of fluid but this really only applies to cases of chronic anæmia, for increasing the corpuscle content above the normal increases the viscosity of the blood and thereby the peripheral resistance throwing a greater strain on the heart. The treatment varies from case to case but very often venesection is of value

(3) *Incompatibility* Reactions due to incompatible blood are usually the result of technical or clerical errors, although occasionally when blood is required urgently the trouble is due to antibodies of the anti Rhesus type which cannot be detected in the short time available. The most dangerous reactions are those following transfusions given when the patient is anæsthetized and cannot complain, for if the blood is stopped whenever the patient has such symptoms as tingling sensations, precordial oppression, pain in the back or thighs, or shows signs of restlessness, anxiety flushing of the face, increasing pulse or respiration rates the outcome is usually favourable, for death has not been recorded with amounts under 300 ml.

If despite these warnings, the transfusion is continued, the patient's condition deteriorates Nausea, vomiting and severe shock develop followed by high fever and in the extreme case delirium and ultimately death.

The incorrect blood cells which have been injected are agglutinated and then broken down (it seems that in addition some of the patient's own cells become involved in the process and are also destroyed) and hæmoglobin, potassium and other breakdown products are liberated. Hæmoglobinæmia and possibly hæmoglobinuria develop the latter depending upon whether the hæmoglobinæmia reaches the level of the renal threshold. Very rarely the donor's blood may contain a powerful antibody a " dangerous universal donor or with a massive group O blood transfusion adequate antibody is given to destroy the recipient's cells.

In patients not dying almost immediately from shock, the bilirubin formed from the breakdown of the hæmoglobin causes jaundice, while as a result of the circulatory upset there may be damage to the epithelium lining the renal tubules leading to oliguria or even anuria. As a result of these renal changes the patient develops uræmia and may die even as late as the nineteenth day Equally well the secretion of urine may recommence at any time often around the eighth day and recovery take place with progressive regeneration of the tubular epithelium, so that hope should not be abandoned even in severe cases (see the section on shock)

To prevent such reactions the greatest care must be taken to avoid errors, particularly clerical errors, by doubly checking all results and tallying all reports against the original figures recorded at the time the examination was made. Even these checks are not infallible and this is one of the reasons why it is particularly important that every bottle of blood should be matched against a guaranteed and properly labelled sample of the recipient's blood by the methods already discussed.

It cannot be overemphasized that there is a greatly increased risk in the case of recipients who have had previous transfusions and to a modified extent women who have been pregnant particularly when they are Rhesus negative and that in these cases the simple tests for grouping and compatibility may not be sufficient to detect the presence of acquired immune antibodies (see the section on the blood groups)

Should such a transfusion reaction develop the blood must be stopped at once and the immediate treatment for shock instituted The foot of the bed should be elevated, warmth provided, particularly about the trunk and a sedative given if necessary An oxygen tent may help by increasing the O_2 content of the blood which will tend to have a lowered saturation and " Cytochrome C " may be given in the hope of increasing the utilization of the available oxygen. It may help to give an " autotransfusion by bandaging the limbs from the hands and feet upwards with crêpe bandages. While it is probably true that the correct treatment is to give compatible blood at once the cause of the incompatibility is not usually so obvious as to make this a practical suggestion.

In addition to treating the immediate effects of the shock, efforts must also be directed to preventing or at least minimizing the damage to the renal tubules, by keeping up the renal blood flow and watching the alkaline reserve of the blood. The measures already discussed aid in this direction, but they can be supplemented by giving plasma or better concentrated salt

free human albumin intravenously Steps must also be taken to insure that there is an adequate fluid intake and a small quantity of saline intravenously will help but this must not be overdone for it is most important neither to waterlog the patient nor upset his blood chemistry by excess of sodium chloride or alkali (see Chapter 5)

In addition to the more severe type of reaction just described minor degrees also occur where the antibody titre is low In these quiet reactions the corpuscles are destroyed less rapidly and the hæmoglobin simply fails to rise as a result of the transfusion It is then very important to check the recipient's blood again for a further transfusion may be disastrous In such a case it must be borne in mind that there may be a "negative phase" for two or three days after a reaction during which all the antibodies have been adsorbed by the incompatible cells.

Delayed Reactions. A number of cases of syphilis malaria and hepatitis transmitted by transfusions have been recorded The risk appears to be very slight and from innumerable transfusions only a handful of such cases have been reported. The possibility however must be kept in mind particularly when choosing donors and it should not be forgotten completely that other diseases with long incubation periods may well be transmitted although they have escaped notice up to the present.

There also appears to be the possibility of starting an allergic state through a transfusion but such cases are very difficult to prove

Immunological Complications. Any difference in the protein structure of the donor's and the recipient's blood is potentially dangerous but the real danger lies in those differences which are powerfully antigenic. These easily evoke antibody formation in a reactive recipient and thereby lay up trouble so that the subsequent injection of a similar antigen precipitates a violent reaction.

This principle was well illustrated in the disasters which overtook the early exponents of blood transfusion The first injection of sheep blood produced as a rule a not unfavourable result but the second, given after an interval was catastrophic.

With the natural antibodies present in human blood transfusions were a gamble until Landsteiner discovered the ABO system From then onwards first transfusions were found to be almost completely safe but it became well recognized that the giving of multiple transfusions or of transfusions to women in the puerperium was dangerous.

The subsequent discovery of the subgroups of the ABO system, the Rhesus system and the various other possible antigen-antibody reactions discussed under the blood groups, which may give rise to immune antibodies following a transfusion or a pregnancy have explained almost all these reactions.

The dangers so far mentioned have been concerned with corpuscle antigens, but the possibility of plasma differences causing difficulties may have to be considered and it is for this reason that one donor should not be used repeatedly for the same patient for example in treating a hæmophilic.

As these immunological complications have already been discussed in detail in other sections, it is sufficient to recall that their danger is enhanced by the fact that immune antibodies are active at 37° C. but not at room temperature, and that they are often inactive in saline solution and require albumin techniques or the indirect Coombs's test for their demonstration

The Investigation of a Transfusion Reaction. While the number of transfusion reactions should be minimal it is not possible to avoid them entirely and it is well to be prepared to investigate any reaction so as to be able to apply the appropriate treatment, thus avoiding recurrence.

Immediately a reaction becomes obvious except perhaps with the mild febrile reactions or slight urticarial rashes the blood should be stopped and general treatment carried out as outlined under the different types of reaction. As soon as this has been done, an attempt to find the cause should be made and perhaps the most important thing is to see that the remaining part of the blood or any other solution which has been given, is kept under sterile conditions for bacteriological and hæmatological examination. Any bottle used should be put into a refrigerator as soon as the top if still sterile, has been replaced or it has been covered with a sterile swab.

The patient should be examined to eliminate other possible causes of such a reaction, for the rising temperature of acute sepsis might easily be mistaken for a reaction to the blood

In allergic reactions it is wise to reinvestigate the question of the patient's sensitivity for unless specifically asked for a long history of asthma or hay fever may not be disclosed. In cases where there is no such history the possibility that the donor has unusual breakdown products in his blood should be investigated

In an incompatible reaction the possibility of previous transfusions or pregnancies should be re-examined.

A fresh sample of the patient's blood should be taken for testing against the donor's blood to eliminate missed antibodies or the possibility that the original sample came from another patient and had been wrongly labelled If no cause for the reaction is found a further sample should be taken four or five days later for antibodies may have been neutralized by the blood given

Except in the allergic reactions the blood and other fluids should be investigated bacteriologically and all the hæmatological tests should be rechecked. A direct Coombs test performed on the patient's corpuscles collected during or after the reaction may reveal an adsorbed antibody

The new sample of the patient's serum should also be examined spectroscopically for hæmoglobin and methæmalbumin and the bilirubin content estimated chemically All urine should be collected measured and examined spectroscopically for blood pigments.

Finally the patient should be watched for the development of jaundice or any diminution in the urinary output.

Chapter 7

MALIGNANT DISEASE

Incidence of Cancer

The incidence of malignant disease in Great Britain is not known since this is not a notifiable disease On the other hand registration of cases by hospitals is becoming more efficient and it is estimated that about half the total number of cases occurring are now registered What is known with considerable accuracy is the mortality of the disease For some sites with high mortality rates the bronchus and stomach for example the incidence and mortality are probably not very different For the skin the number of deaths per annum would be no indication at all of the number affected

Cancer kills more people than any other group of diseases except those of the circulatory system Table A gives the Registrar-General's figures for 1956 in England and Wales (population 44 800 000) for the commoner sites. Figures are to the nearest multiple of ten and are arranged approximately in order of frequency It should be noted that the figures for lung cancer are for primary neoplasms. Metastatic deposits add another 4,200 male deaths and 690 female deaths.

TABLE A

Deaths from Cancer in England and Wales in 1956, showing the Commonest Sites of Primary Tumours

Total Cancer Deaths 94,360

Men 49 680		*Women* 44 680	
Lung	11 410	Breast	8,580
Stomach	7 750	Stomach	6,200
Colon	3 810	Colon	5 470
Rectum	3 170	Rectum	2,380
Prostate	3,550	Ovary	2,810
Blood and lymphatics	2,540	Cervix uteri	2,510
Bladder	2,020	Corpus uteri	1 180
Pancreas	1 850	Blood and lymphatics	2,120
Mouth and pharynx	1,230	Lung	1 880
		Pancreas	1,560

In the last ten years there has been an upward trend in deaths from cancer of the lung, breast, bladder prostate, pancreas, ovary blood and lymphatics There has been a downward trend in deaths from cancer of the stomach colon, rectum, mouth and pharynx. The figures for the uterus have remained more or less the same

The Investigation of a Transfusion Reaction. While the number of transfusion reactions should be minimal it is not possible to avoid them entirely and it is well to be prepared to investigate any reaction so as to be able to apply the appropriate treatment, thus avoiding recurrence.

Immediately a reaction becomes obvious except perhaps with the mild febrile reactions or slight urticarial rashes, the blood should be stopped and general treatment carried out as outlined under the different types of reaction As soon as this has been done, an attempt to find the cause should be made and perhaps the most important thing is to see that the remaining part of the blood or any other solution which has been given is kept under sterile conditions for bacteriological and hæmatological examination Any bottle used should be put into a refrigerator as soon as the top if still sterile, has been replaced, or it has been covered with a sterile swab

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Except in the allergic reactions the blood and other fluids should be investigated bacteriologically and all the hæmatological tests should be rechecked. A direct Coombs test performed on the patient s corpuscles collected during or after the reaction may reveal an adsorbed antibody

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Finally the patient should be watched for the development of jaundice or any diminution in the urinary output.

Mesenchymal Non-hæmopoietic

Innocent
- [illegible]
- [illegible]
- Lipoma (fat)
- Myoma (muscle)
- Myxoma (mucoid tissue)
- Chondroma (cartilage)
- Osteoma (bone)
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- Synovioma (synovial membrane)

Locally Malignant [illegible]

Malignant Sarcoma. All the above tissues may give rise to malignant neoplasms. The appropriate prefix is added. Thus Osteosarcoma, Synovial sarcoma, etc.

Mesenchymal Hæmopoietic

[illegible]
- Lymphosarcoma
- Lymphatic leukæmia
- Lymphadenoma (Hodgkin's disease)
- Reticulosarcoma

Solitary and multiple myeloma (plasmocytoma)
Myeloid leukæmia
Polycythæmia

Neural Tissue

Innocent Neurofibroma
Malignant Glioma
- Neuroblastoma and ganglioneuroma
- Retinal and ciliary tumours
- Chromaffinoma

Other Neoplasms

Melanoma (pigmented tissue)
Chorionepithelioma (placenta)
Teratoma (multiple tissues)
Nephroblastoma (kidney)

The Spread of Tumours

The view used to be held that a tumour grew entirely by multiplication of its own cells, in other words, that all neoplastic growth could theoretically be traced back to one cell which changed in some way from its normal nature. Most pathologists now believe that this is not so but that cancer has a multicentric origin and that tumours develop from small or larger areas of tissue by proliferation and by neoplastic change in the tissues between these areas. Continued growth takes place by expansion and by infiltration.

Infiltration. This is one of the features distinguishing a malignant from an innocent growth. The routes of invasion are as follows:

(1) *Tissue Spaces.* Although to the naked eye a tumour may appear circumscribed, microscopic examination will show cells budding out into the surrounding tissue spaces and often following cleavage planes.

The Pathology of Tumours

It is not at all easy to define a tumour for the cells of which it is composed may not differ in kind but only in degree from the normal cells of the body The definition proposed by Willis is as satisfactory as any

> A tumour is an abnormal mass of tissue the growth of which exceeds and is unco-ordinated with that of the normal tissues and persists in the same excessive manner after cessation of the stimuli which evoked the change

This definition seeks to distinguish true neoplasia from inflammatory and reparative proliferations, from hyperplasias and from congenital or acquired malformations of tissue It does not of course distinguish innocent from malignant tumours a difference which it is now recognized is not at all sharply defined For example "benign papillomata of the bladder intestine and breast may all in time infiltrate and metastasize The slow growing salivary gland tumours, osteoclastomas and chondromas are often difficult to classify as either innocent or malignant

Table B however indicates the differences between these two classes of neoplasm

TABLE B

The Distinguishing Features of Malignant and Innocent Tumours

	Innocent Tumour	*Malignant Tumour*
1 Structure	Structure often typical of the particular tissue of origin	Structure often atypical, *i.e* differentiation imperfect
2. Mode of growth	Growth usually purely expansive, and a capsule formed	Growth infiltrative as well as expansive so that strict encapsulation is absent
3 Rate of growth	Growth usually slow mitotic figures scanty	Growth may be rapid with many mitotic figures
4 End of growth	May come to a standstill or retrogress	Growth rarely ceases, usually progresses to a fatal termination
5 Metastasis	Absent	Frequently present
6. Clinical results	Dangerous only because of position, size, or accidental complications	Intrinsically dangerous because of progressive infiltrative growth and metastasis by lymphatics and blood stream

Classification of Tumours. This should be based on histogenesis, that is to say the kind of tissue from which tumours develop and of which they consist. But the behaviour of the tumour must also be taken into account and hence a classification should also indicate where possible whether a tumour is innocent or malignant.

Epithelial

Innocent Papilloma (surface epithelium)
Adenoma (glandular epithelium)
Malignant Squamous carcinoma (surface epithelium)
Adenocarcinoma (glandular epithelium)

Mesenchymal Non-haemopoietic

Innocent
- Angioma (blood vessels)
- Fibroma (connective tissue)
- Lipoma (fat)
- Myoma (muscle)
- Myxoma (mucoid tissue)
- Chondroma (cartilage)
- Osteoma (bone)
- [illegible]
- Odontoma (teeth)
- Chordoma (notochord)
- [illegible] tissue)
- Synovioma (synovial membrane)

Locally Malignant Osteoclastoma (bone)

Malignant Sarcoma. All the above tissues may give rise to malignant neoplasms. The appropriate prefix is added. Thus Osteogenic sarcoma, Synovial sarcoma, etc.

Mesenchymal Haemopoietic

Lymphoid tissue tumours
- Lymphosarcoma
- Lymphatic leukaemia
- Lymphadenoma (Hodgkin's disease)
- Reticulosarcoma

Solitary and multiple myeloma (plasmocytoma)
Myelocytic leukaemia
Polycythaemia

Neural Tissue

Innocent Neurofibroma

Malignant Glioma
- Neuroblastoma and ganglioneuroma
- Retinal and ciliary tumours
- Chromaffinoma

Other Neoplasms

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Infiltration. This is one of the features distinguishing a malignant from an innocent growth The routes of invasion are as follows

(1) *Tissue Spaces* Although to the naked eye a tumour may appear circumscribed microscopic examination will show cells budding out into the surrounding tissue spaces and often following cleavage planes

(2) *Lymphatic Permeation* Many neoplasms spread in this fashion and in addition to the commonly described interstitial lymphatics perineural and perivascular channels are also involved. In the larger lymphatics emboli of tumour cells pass to the regional nodes Handley's theory that an obliterative fibrosis follows the permeation along the lymphatics so that there is a cancer-free area between the primary and the extending edge of the growth does not find favour with many pathologists

(3) *Invasion of Veins* Cancer cells easily penetrate the walls of veins and capillaries and proliferate within them By contrast, arteries are very seldom affected in this manner Emboli bear the tumour cells to distant locations but in addition thrombosis occurs ahead of the tumour the cells of which



FIG 7 1 PULMONARY METASTASES IN A PATIENT WITH CARCINOMA OF THE BREAST

grow into the clot, a process of malignant organization Venous emboli from growths within the systemic blood system will tend to be held up in the capillaries of the lungs while those from the portal system will go to the liver

(4) *Invasion of Body Cavities* Intraperitoneal deposits arise from the direct shedding of malignant cells by growths of the abdominal viscera. The same applies to deposits in the parietal pleura In cases of malignant ascites or ovarian metastases from carcinoma of the breast it is possible that the cells gain entry to the peritoneal cavity through the lymphatics of the abdominal wall but it is more probable that such metastases come from emboli.

(5) *Implantation*. [illegible] tract tumours [illegible] bladder. The same is true of [illegible] along the surface of the spinal cord. In the [illegible] permission.

Aetiology of Cancer

Two lines of research are available in the field: (a) the experimental production of tumours in animals, and (b) statistical studies regarding occupational or racial factors in humans. Certain facts are well proved.

(1) There is at present no evidence of any specific factor which can be held directly responsible for the capacity for the unlimited growth which neoplastic cells display.

(2) Chronic and long-continued irritation with or without infection is a common precursor of tumour formation, which may be delayed for many years after the irritation has ceased.

(3) Misplaced and undeveloped cells, the result of embryological maldevelopment, are very prone to give rise to new growths.

(4) Certain hydrocarbons—e.g. benzpyrene—of relatively simple chemical constitution will produce epithelioma if applied to the skin, and sarcoma if injected into the connective tissues of susceptible animals.

(5) Other chemical carcinogens, particularly dyes and aromatic amines, exist in large numbers.

(6) Naturally occurring hormones—e.g. oestrone—may cause cancer in susceptible animals.

(7) Radiations, particularly ultra-violet rays and X-rays, cause cancer sometimes many years after exposure.

These statements may be elaborated somewhat. Heredity is known to be of significance in some tumours, for instance multiple polyposis of the colon, familial retinoblastoma and xeroderma pigmentosum, and there is some evidence that its influence may operate in carcinoma of the breast. Prolonged suppuration, as in osteomyelitis, may predispose to the development of cancer and this change may also occur in scarred tissues such as result from burns. The association of syphilis and cancer of the mouth is well recognized and the trauma associated with multiparity is supposed to account for the increased incidence of carcinoma of the cervix uteri in women who have borne many children. Seminoma occurs more frequently in ectopic testis than in fully descended testis. Teratoma is often malignant.

The number of proved occupational cancers is constantly increasing. Chimney-sweep's cancer and mule-spinner's cancer have been known for many years. So have other skin epitheliomata associated with prolonged exposure to tars and oils. More recently the occupational incidence of papilloma and carcinoma of the bladder among workers in the aniline-dye industry has been recognized. At present there is very strong statistical evidence that cancer of the lung is associated with cigarette smoking, though the carcinogen responsible has not been isolated. The conception of endogenous carcinogens, that is to say substances produced in the body by normal metabolic processes, is gaining ground though the theory remains speculative. But the close chemical relationship between carcinogenic hydrocarbons and the bile acids, for instance, lends support to this view.

The field for clinical research is indeed vast Why does the pattern of cancer incidence in various sites differ in one country from another? Why is cancer of the cervix less common in Jewish women? Is there such a thing as a breast-cancer producing substance (the "milk factor") transmitted in the milk of humans as there is in susceptible strains of mice? Will the increase in radioactivity in the world to-day be the cause of genetic mutations and possibly of an increase in cancer in the future? These are just a few of the problems which await solution

Diagnosis

The successful treatment of malignant disease is almost entirely dependent on early diagnosis It is true that the histological type of cell is a factor of prime importance in determining the rate of growth and metastatic spread and that, however early in the clinical sense a growth may be the prognosis may be hopeless Yet it is surely true that the sooner a growth is treated after its inception the better the chance of cure Much effort is devoted to educating the public about the early symptoms of cancer but it is also necessary to emphasize to the student and the doctor that the possibility *of malignant disease should always be in mind and that immediate steps* should be taken to refer patients for consultation and investigation. Unhappily many clinical descriptions emphasize the established physical signs of advanced cancer rather than the less obvious but far more important early symptoms and signs Table C gives an indication of the more common sites in which cancer occurs together with the earliest symptoms and the most necessary investigations for confirming or excluding the disease Although malignant disease in the main affects people of middle age or later years, it should be remembered that no age is exempt and it is therefore unwise to assign ages to the various sites

The commonest sites are in bold print and it is worth considering these in a little more detail

Stomach Although recent dyspepsia is a symptom in the majority together with anorexia and some loss of weight, *it should be noted that in* nearly a quarter of cases there is a longstanding history of indigestion and even *of proved peptic ulceration.*

Colon and *Rectum.* Altered bowel habit is necessarily rather a vague term but if a man or woman after forty years of age finds that a regular daily evacuation ceases to be the rule or that slight degrees of constipation and diarrhœa persist for any length of time, then investigation of the bowel becomes a necessity Digital examination of the rectum must never be neglected. Three-quarters of all rectal tumours are palpable by this simple means Ideally everyone over forty should be sigmoidoscoped annually

Bronchus There seems to be no means of detecting these cases early except by routine chest X rays Nevertheless, it must be emphasized that virus pneumonia in the middle-aged man or an unresolved patch or recurrent pneumonia *should be regarded with the gravest suspicion.*

Breast All women should be encouraged to examine their own breasts once a month and to report any lump to their doctors The first day of each month should be chosen it is easy to remember and during the course of the year the breasts will be examined during all phases of the menstrual cycle The best position to adopt is lying down The outer *half* of the right breast is palpated with the fingers of the left hand, the right arm being kept

TABLE C

The [illegible] Onset

Site	Sex	Type of Symptom	Investigation (Biopsy ... [illegible])
Alimentary Canal			
Lip	M F	[illegible]	
Tongue and Mouth	M F	Soreness Tumour	
Oesophagus	M F	Dysphagia	(1) Barium swallow (2) Oesophagoscopy
Stomach	M A F	[illegible]	(1) Barium meal (2) Gastroscopy
Colon	F A M	Alteration bowel habit	Barium enema
Rectum	M F	Alteration bowel habit or passage of blood	(1) Digital examination (2) Sigmoidoscopy
Anus	M F	Pain	
Pancreas	M A F	Colicky pain	Laparotomy
Respiratory Tract			
Nasal sinuses	M F	Pain and blood-stained discharge	Skiagram
Larynx (intrinsic)	M F	Hoarseness	Laryngoscopy
Larynx (extrinsic) [illegible]	M A F	Pain on swallowing	Laryngoscopy
Bronchus	M F	Dry cough, lobar collapse	(1) Skiagram (2) Bronchoscopy
Urinary Tract			
Kidney	M F	Painless haematuria	Pyelography
Bladder	M F	Painless haematuria	Cystoscopy
Prostate	M	Difficulty and frequency	Digital examination
Genital Organs			
Breast	F (M)	Tumour	Exploration, Biopsy
Cervix Uteri	F	Irregular bleeding or discharge	Digital examination
Corpus Uteri	F	Bleeding (usually post menopausal)	D and C
Ovary	F	Pelvic tumour	Laparotomy
Testis	M	Tumour	Exploration, Biopsy
Other Sites			
Bones	M A F	Pain, Tumour	Skiagram
Thyroid	F M	Goitre, recent onset or rapid growth	Exploration
Brain	M A F	Headache, vomiting	Ventriculography
Lymph Nodes (primary)	M A F	Rapid, painless enlargement	Biopsy
Skin (rodent ulcer or squamous)	M F	Nodule or ulcer	—
Skin (melanoma)	M A F	Mole, increase in size or pigmentation	Wide excision

alongside the chest for the inner half the arm should be raised above the head

Cervix Carcinoma occurs commonly in premenopausal women in whom irregular bleeding is more apt to be overlooked Routine examination of the cervix by direct vision or cervical smear is an ideal to be achieved by educating the public and the medical profession

Skin Theoretically no malignant lesions of the skin should ever be allowed to achieve any size before being reported and since rodent ulcer and squamous-celled carcinoma are both eminently curable this is a site where public education is thoroughly justified Melanoma is in a somewhat different category because of its extreme malignancy and disposition to spread literally like wildfire if cut into Any mole which is suspect on account of recent increase in size depth of pigmentation or ulceration should be widely excised in order to determine its nature It is never justifiable to remove a piece for biopsy

Ancillary Investigations. *Endoscopy* No assessment of the upper air passages *bronchi, œsophagus and stomach lower bowel renal tract or* vagina is complete without examination by endoscopes To these may be added thoracoscopy and peritoneoscopy Frequently the purpose of such an inspection is to obtain a portion of the tumour for histological examination

Skiagraphy The scope of X rays for diagnostic purposes continually expands The use of contrast media enables the radiologist to visualize most of the internal organs and tomography permits the localization of many " space-occupying " lesions The alimentary tract can be outlined with barium, either swallowed or administered as an enema. The biliary passages can be made visible owing to the excretion of iodine compounds by the liver The renal tract can be studied by excretion or injection pyelography Lipiodol can be used in many hollow viscera or ducts Air replacement of the cerebrospinal fluid allows ventriculography to be performed The blood supply of tumours is studied by arteriograms and venograms

Hæmatological and Biochemical Tests It is not possible to list all those that are available for the investigation of tumours in different sites But their application to any of the neoplasms of the hæmopoietic system is obvious There are a few almost specific tests for cancer of certain organs *Thus a high serum acid phosphatase is diagnostic of carcinoma of the* prostate and Bence-Jones proteose occurs only in the urine of patients suffering from multiple myelomatosis A universal test for cancer is unlikely to be discovered owing to the diverse nature of the group of diseases concerned.

Isotope Studies. Much experimental work is in progress Many compounds can be " labelled " with radioactive " tracers," the distribution and excretion of which in the body can be studied by monitoring methods Some tumours concentrate such tracers sufficiently to enable them to be localized The best known example is the uptake of [illegible] ve iodine by the metastases from [illegible] carc[illegible] the thyr[illegible] gland after total thyroidecto[illegible]

The removal of small p[illegible] from the [illegible] is now [illegible] established as an important [illegible] there is the fullest co-operat[illegible] Bi[illegible] frequently used [illegible] mal[illegible] newer [illegible] its [illegible] of [illegible]

Whatever method of biopsy is employed there are certain general principles which should be followed in order that the best results may be attained.

General Principles of Biopsy. However the material is obtained, immediate and adequate fixation is imperative. Bad fixation certainly accounts for the large majority of failures to produce satisfactory information. In the majority of cases 5 per cent. saline formaldehyde (12.5 volumes of 40 per cent. formaldehyde to 87.5 volumes of normal saline) is a perfectly adequate fixative, but in the difficult case the pathologist should be consulted as to what form of fixative should be used.

When a biopsy is performed on a suspected malignant growth it is of utmost importance that the piece of tissue be taken through the edge of the growth so as to include some normal tissue, and the fragment removed should be large enough to obtain clear evidence of the presence or absence of invasion. The pathologist must be supplied with clinical information to guide him in the histological diagnosis and in the choice of methods of staining to be employed. A piece of tissue may be very small and yet a frozen section stained for fat may be the most important investigation to be performed. Without adequate information all the tissue may be blocked in paraffin, making it impossible for frozen sections to be cut later on. It is in the difficult case that biopsy may be most valuable and it is then that a close liaison between the surgeon and pathologist is essential for success.

It should be accepted as a golden rule that when a malignant growth is strongly suspected clinically and the biopsy report is negative, the biopsy should be repeated. Similarly, if the result of a biopsy is quite unexpected, it should be regarded with suspicion by the clinician until confirmed by a repeat biopsy.

Indications for Biopsy. There are two groups.

Diagnosis and Treatment of Tumours. The most obvious and most frequent use of biopsy in relation to tumours is in the differentiation of innocent and malignant growths. This is particularly true of those parts of the body where cancer is often the result of malignant change arising in an innocent tumour. A "rectal polyp" may be a simple adenoma or papilloma or malignant change may have supervened. Only histological examination of part or the whole of such a tumour can give the answer. Here it may be as well to stress the importance of always submitting to histological examination everything that is "cut out" of a patient, however small. Failure to do so will sooner or later lead to disaster. The innocent looking cervical polyp which clinically gave no suspicion of malignancy may be a pedunculated adenocarcinoma. It is better to err on the side of safety than to miss such a case.

Although the diagnosis of cancer may appear obvious, a confirmatory biopsy should be performed before the patient is submitted to an extensive and possibly mutilating operation. Some manifestations of amoebic dysentery, for example, may closely resemble carcinoma; so may a chancre in an unusual site. Similarly, endometriosis or lymphogranuloma venereum in the female may simulate a malignant stricture. Most important of all, the breast tumour should always be submitted to a frozen-section examination before mastectomy is performed. Fibro-adenoma is often confused with carcinoma on naked-eye examination and it has been reported that 3 per

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Biopsy

The removal of small pieces of tissue from the living body is now well established as an important diagnostic procedure, always providing that there is the fullest co-operation between surgeon and pathologist Biopsy is still most frequently used to confirm a clinical diagnosis of malignant disease, but newer methods of obtaining material have increased its scope and value Sternal puncture and punch biopsy of the liver for example, are of great value in diagnosis and have added considerably to our understanding of the pathogenesis of diseases of the liver and hæmopoietic organs

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cent. of radical mastectomies performed for carcinoma (without biopsy) prove to be fat necrosis But worse still are the occasions upon which a small lump is inadequately removed and the report of carcinoma is not forthcoming for two or more weeks

Quite apart from the diagnosis of malignancy biopsy may be of the greatest value in deciding on the best line of treatment to be adopted Whether a malignant growth is best treated by excision or by radiotherapy may depend on its degree of differentiation which is determined by biopsy This is particularly true of cancer of the larynx and of the cervix In such cases repeat biopsy may be necessary to follow the results of treatment

The diverse causes of a generalized lymphadenopathy and splenomegaly frequently present a uniform clinical picture and diagnosis may only be possible by the removal of a lymph node. In such a case the selection of which lymph node to remove and the manner of its removal are of great importance. Unless they are the only accessible enlarged nodes inguinal lymph nodes should never be removed for diagnosis in a lymphadenopathy of unknown origin. These nodes have been subjected for many years to chronic inflammatory changes resulting from various infections and trauma to the legs. Such changes may obscure the histological picture and make the diagnosis very difficult or uncertain. The lymph nodes of choice are those in the neck or axilla. If possible the surgeon should remove more than one node choosing for preference one that has enlarged recently and one that has been enlarged for some time. The nodes should be removed by careful dissection so that their capsules are intact, and immediate and adequate fixation is imperative.

Diagnosis of Diseases Other than Tumours The field to-day is almost limitless. Perhaps the most frequent use of biopsy in non malignant conditions is found in the investigation of endocrine dysfunction of the endometrium The modern use of out patient diagnostic curettage brings much material to the histologist. Its use in the investigation of female sterility may bring to light, occasionally the clinically latent case of tuberculous endometritis as well as assisting in the control of hormone therapy when histology has revealed an abnormal endometrial pattern.

In the male, testicular biopsy is much less frequently resorted to as in the majority of cases examination of the seminal fluid gives all the information that is required Azoospermia however may be caused either by inactivity of epithelium lining the seminiferous tubules or by some defect of the ejaculatory apparatus. It is in such a case that testicular biopsy may be necessary

The obtaining of a minute piece of tissue by aspiration of an organ has been in use for a long time. It may be of particular use in the investigation of such diseases as kala-azar when only a splenic or sternal puncture and the identification of the organisms within the cells so obtained can enable a certain diagnosis to be made. Similarly aspiration of a lymph node is the quickest way of diagnosing trypanosomiasis Indeed, lymph node aspiration is a useful and all too infrequently used measure in the differential diagnosis of the enlarged lymph nodes seen in ordinary practice.

The establishment of a safe technique for obtaining pieces of liver tissue for examination without having to resort to laparotomy has been an important development in recent years. Apart from the differentiation of the cirrhoses of the liver the use of punch biopsy may reveal unexpected

secondary deposits and be of assistance in the diagnosis of obscure hepatomegaly in the child

Contra-indications to Biopsy Apart from the possible risk of hæmorrhage following liver or splenic puncture the only objections raised to biopsy have been in its use in malignant growths It has been argued that incision into a malignant tumour stimulates local growth and that the trauma incident to incision stimulates the dissemination of cancer cells and thereby increases the incidence of distant metastases

A considerable amount of experimental work has been carried out on animals in whom malignant growths have been induced by various means in an attempt to answer these important objections No evidence has been produced to support the hypothesis that incision of a malignant growth increases the incidence of metastases The only procedure which would appear to do this is prolonged massage of the growth

Methods of Biopsy *By Excision* The removal of a piece of tissue is the commonest method employed A good paraffin section can be made in twenty four hours and many pathologists prefer reporting on such a section Yet by the *frozen-section* technique sections may be produced in a very few minutes in the operating theatre and the pathologist may there and then make a diagnosis The sections so obtained are never entirely satisfactory But the method in the hands of an experienced pathologist is of the greatest value especially as already stated in tumours of the breast.

By Aspiration Apart from the aspiration of tissue from organs in the diagnosis of such diseases as kala azar this procedure is now being used more frequently in the diagnosis of malignant disease Its main advantage is simplicity which enables the method to be applied to out patients. It is of particular use in the diagnosis of obscure deep-seated lesions in the thorax or in the skeleton in which biopsy by ordinary means would necessitate a major surgical operation

The main disadvantage of aspiration biopsy is the very small piece of tissue obtained and considerable experience in its use is needed before reliable results can be attained

By Punch This method has been developed during the last ten years especially for the investigation of liver disease These patients are frequently *jaundiced and there is a risk of hæmorrhage but this is very slight if adequate* doses of vitamin K are given beforehand. The method is also applicable to any accessible tumour The punch may take the form of special forceps, a cutting-edged cannula or a Silvermann needle. The latter consists of a bifurcated needle which is passed through a cannula after this has been inserted into the growth. The needle is longer than the cannula and the two halves splay outwards into the tumour Pushing the cannula forwards presses a small core of tissue into the hollow of the blades.

By Drill A hollow dental drill may be employed for deep seated lesions, particularly in bone A high-speed pneumatic drill is now available and its hollow needle produces an excellent core of tissue which is not distorted It is very suitable for all accessible tumours, whether of soft tissue or bone. Its only disadvantage is the noise it makes.

By the Wet Film Technique This method of biopsy is used most frequently in neurosurgery in the diagnosis of tumours explored with the brain needle The method consists in spreading the small piece of tissue obtained with a brain needle on a slide in a manner similar to the making

of a blood film. The smear while still wet, is fixed and stained, the whole procedure taking only about ten minutes to perform

The Principles of Treatment

The purpose of treatment is naturally the total eradication of the neoplasm In practice all too often, the clinician has to accept the knowledge that the disease is too far advanced either by reason of the extent of the primary tumour itself or because metastases elsewhere in the body make cure an impossibility In these circumstances valuable palliative treatment can often be instituted Results of treatment are nearly always expressed in terms of the five year *survival rate* but in some ways this is a misleading criterion A patient may well be alive five years after treatment though it is obvious that the disease is still present and maybe is in an advanced state It is only necessary to recall that on the average an untreated case of carcinoma of the breast survives three and a quarter years to appreciate this fact. In some ways, therefore, what is termed a *recurrence-free rate* is a more truthful guide to the success of treatment.

Some cancers carry a worse prognosis than others. In general it may be said that cancers fall into three broad groups

Often Curable Cancer of the breast, cervix and corpus uteri skin (including the lip) tongue intrinsic larynx, thyroid, testis and pre-cancerous conditions such as papilloma of the bladder and carcinoma *in situ*

Treatable and Sometimes Curable Cancer of the colon and rectum of the stomach and bronchus (occasionally) kidney bladder and prostate pharynx and extrinsic larynx.

Usually fatal Cancer of the œsophagus, stomach, bronchus, pancreas, gall-bladder sarcoma of bone, glioma, leukæmia and many other neoplastic conditions of the blood forming and lymphatic tissues

It will be observed by reference to the table showing the mortality of cancer in various sites that the commonest growths are generally the most lethal, a state of affairs which is both a challenge and an explanation of the fact that as other diseases claim fewer victims the overall cancer mortality continues to rise.

Cancer is treated by surgery radiotherapy or chemotherapy The latter term is here used in a different sense from that given to the treatment of infections by antibiotics and includes both hormones and synthetic compounds. It should be emphasized that these methods are not exclusive and that although they are described in the following pages under separate headings, they are frequently used in combination either serially or at one and the same time and as part of a planned treatment directed against the known behaviour of the disease And here should be mentioned the absolute necessity of a careful " follow-up " of every patient who has been treated for malignant disease

Surgery No tumour should ever be cut into except for purposes of diagnosis, or unless it is technically impossible to " get beyond " the growth and the risks of spreading it are accepted. Total extirpation of the neoplasm is the objective at which the surgeon should aim but both the site of the tumour and the histological type of cell of which it is composed will often modify this ideal. The surgical methods available in treatment are as follows

(1) Excision of the tumour the viscus containing it, the regional lymph-

nodes and all the intervening tissues is exemplified in the operations of radical mastectomy abdomino-perineal excision of the rectum and pan hysterectomy

(2) A modification of this scheme is the treatment of the primary and regional lymphatic areas separately For example carcinoma of the tongue may be treated by irradiation or excision while a block dissection is performed on the neck again a breast cancer may be treated by local mastectomy and the regional lymphatic areas by X ray therapy

(3) On occasion it may be deemed sufficient to remove only the organ containing the tumour as in pneumonectomy for carcinoma of the bronchus or laryngectomy for carcinoma of the larynx

(4) Complete but local excision of the tumour itself may suffice Skin cancer can be treated thus as can some of the less malignant growths e g sialoma (mixed " tumour) of the parotid and fibrosarcoma of soft tissues

(5) In some situations surgery is used to gain access to a growth In carcinoma of the antrum the treatment of choice may be to expose the growth and remove as much as possible treating the residuum by a radium applicator Similarly the place of surgery may be the excision of residual tumour tissue after irradiation In all such cases the co-operation of surgeon and radiotherapist during all stages of treatment is essential

In one respect cancer surgery differs from all other branches no thought should be given to the amount of deformity produced by operation but only to the necessity of removing the disease. This is particularly the case with regard to tumours of the face and it is a sound principle that the repair should be done by a plastic surgeon The outlook of the two is totally different. The mind of one surgeon should be bent upon destruction of the other upon repair and rehabilitation A useful adjunct in the surgery of malignant disease is the use of diathermy This has both cutting and coagulating high-frequency currents The advantages of using the endothermy knife as it is sometimes called are the control of hæmorrhage from the smaller vessels, the destruction of nerve endings and hence the abolition of pain, and the sealing of lymphatics The coagulating current can often be used for the destruction of growths in the mouth or bladder when resection is not possible.

Surgery may be of use also in the palliative treatment of cancer particularly as regards the relief of pain. This is further discussed in the section devoted to The Advanced Case (p 143)

Radiotherapy Soon after the discovery of X-rays by Roentgen in 1895 it was found that they were capable of setting up severe dermatitis, often accompanied by ulceration and also had a considerable depilatory power It was also soon observed that repeated exposures might lead not only to dermatitis and X-ray burns, but also under certain conditions to the development of actual neoplasms blood changes of a serious type also followed The genital cells were found to be remarkably susceptible to the action of the rays, the germinal cells of both testis and ovary being easily and permanently damaged with the subsequent production of sterility and, as recent evidence has shown genetic effects. From these facts it is evident that radiotherapy must invariably be carried out with due regard to the safety of both patient and operator

Dosage Measurement Because all ionizing radiations produce marked

changes in tissues it is essential that an accurate means of measuring the dose given should be available. The empiricism of early treatments by X rays and radium has been replaced by an internationally standardized technique based on an estimation of the amount of energy absorbed in all parts of the tissue irradiated This is known as the *volume distribution*. The unit of radiation the roentgen or *r* is defined as the quantity which will under certain standard conditions, produce a given amount of ionization in air Another standard now agreed, is the *rad*, which is defined as the unit of absorbed dose per unit mass of irradiated tissue it is 100 ergs per gramme

Sensitivity of Tumours The response of malignant tumours to radiotherapy is very variable and unpredictable They may however be roughly divided into three groups (*a*) *highly radiosensitive* (lymphosarcoma, seminoma lymphadenoma, medulloblastoma) (*b*) *moderately radiosensitive* (squamous-celled carcinoma, spheroidal-celled carcinoma, some adenocarcinomata) (*c*) *radio-resistant* (fibrosarcoma, some forms of osteogenic sarcoma, and malignant melanoma) Dosage necessarily varies but it may be broadly stated that for the first of these groups 3 000 *r* will result in the death of malignant cells, for the second group 5 000–6 000 *r* will be required and that for the third a dosage of 8 000 *r* administered over a long period may well be needed and often fails in its purpose.

X-ray Therapy X rays are electromagnetic waves of much shorter wave length than those of infra red, visible or ultra violet light, but not as short as the γ-rays of radium. The higher the voltage used, the shorter the wave length and the greater the penetrating power (hard rays) Screening with aluminium copper or tin is employed to cut off the rays of longer wave length and less penetration (soft rays)

One of the dangers in connection with X ray therapy is that its effects on tissues are not apparent at once a certain latent period elapses between exposure and any obvious change, varying with the conditions and the individual, but it is generally from a week to fourteen days. If therefore, a skin surface is irradiated and the dose repeated before the time has elapsed for the former dose to have produced a reaction a cumulative effect will result.

Other late effects following irradiation of the skin are the production of pigmentation, which may occur at any time up to two or three months following the erythema and telangiectases after a latent period of up to five years. Deeper tissues undergo a similar necrosis, the development of which may take many years in some instances. Tissues with a poor blood supply notably cartilage, are particularly liable to be affected. Osteitis, with sequestrum formation, fibrosis of many organs (the lung for instance after heavy irradiation of the breast area) and damage to growing epiphyses are other examples of the possible ill-effects of irradiation. The development of X-ray skin cancer has already been alluded to and an analogous form of disease is the leukæmia to which radiologists are often martyrs.

Methods of therapeutic application of X-rays are

Low-voltage Therapy X rays of comparatively long wave length generated at low voltages (30 to 60 kV) are employed The target of the X-ray tube is placed close to the skin (contact therapy) The destructive effect is limited to the area to be treated by special metal applicators. Limited penetration is ensured both by the short focal skin distance and the nature of the radiation. The method is particularly suitable for the treatment of

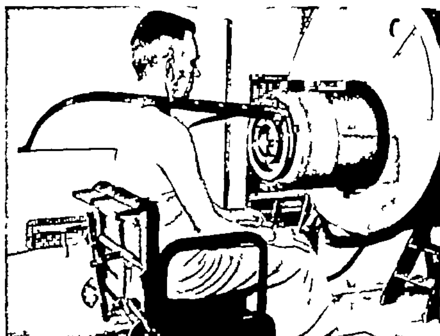


FIG 7 3 A PATIENT WITH CARCINOMA OF THE BRONCHUS UNDER TREATMENT WITH A VAN DE GRAAFF 2 MEV MACHINE. (*Royal Marsden Hospital*)

absorption of super voltage radiations in tissues of different densities tends to become equalized.

Radium Therapy Radium is a metallic element of high atomic weight employed clinically in the form of the salts bromide chloride or sulphate. Being naturally radioactive it decays, but since its half-life is over 1,500 years it remains for therapeutic purposes unchanged a fact which makes dosage calculation easier than for most other isotopes Also unlike many isotopes radium emits three sorts of " rays " (*a*) α particles which are positively charged helium atoms, of exceedingly small penetrating power and therefore useless in treatment (*b*) β-particles, which are negatively-charged electrons, being more penetrating and destructive to all tissues. These may be screened off by 0 5 mm of platinum or 1 mm of lead (*c*) γ-rays, which are electromagnetic rays, similar therefore to X rays but of much shorter wave length than any save those produced in the super voltage machines It requires some 16 mm of lead to screen γ-rays. It appears that these γ-rays have some selective action in the destruction of malignant cells.

Methods of therapeutic application of radium are

Teleradiation (*Beam Therapy*) Large quantities of radium varying from 1 to 10 grammes are enclosed in a special container (radium " bomb ") having lead or tungsten alloy walls which prevent the escape of γ-rays except in the direction desired. The rays escape through an aperture which is screened to prevent emission of β-particles. The beam of γ-rays is directed on to the field decided upon, and multiple fields are used in most cases. Those cases which are best treated by means of the " bomb are carcinoma of the larynx, pharynx and mouth It is the ideal treatment for carcinoma of the posterior third of the tongue and the floor of the mouth as the primary growth and regional nodes are treated at the same time

Similar apparatus is used containing radioactive cobalt, a γ ray emitter comparable to radium Sources equivalent to a thousand grammes of

radium or more are employed With a half life of only five years the apparatus requires calibrating fairly frequently

Surface Application Radium needles are embedded in wax plastic material or Columbia paste which may then be moulded to such parts as the cervix floor of the mouth or skin

Interstitial Radium containers are generally hollow needles or tubes with a minimum wall thickness of the equivalent filtration of 0·6 mm of platinum They are usually made of platinum-iridium alloy as pure platinum is too soft and is liable to bend The radium is uniformly distributed throughout the needle with the exception of the point and eye and the total length and active length should be stated Needles usually contain 0 5 1·0 2·0 or 3·0 mg of radium

Interstitial implantation is most suitable for tumours in the mouth or on the surface of the body According to the size and position of the tumour either a single plane two plane or volume implant is done The number of needles inserted and the activity of each is usually calculated so that they are left *in situ* for six or seven days.

Radon Radon is a radioactive gas resulting from the disintegration of radium and emitting γ-rays. It is collected in capillary tubes and enclosed in gold or platinum " seeds. These seeds are buried in the tissues and within fourteen days have lost 90 per cent of their activity Radon seeds are of use in deep-seated lesions (*e g* bladder) or when the implantation of needles is technically difficult (*e g* the back of the tongue)

Radioactive Isotopes. The study and use of these agents is a recent event. Broadly they may be used (*a*) as tracer doses in diagnosis and circulatory studies and (*b*) in larger amounts for treatment A considerable number of elements may be made radioactive in an atomic pile but their suitability for medical work depends largely on their half-life and upon the manner in which they may be applied Isotopes in use at present include

Cobalt (^{60}Co) As a γ-ray emitter its use in telecurie apparatus has already been mentioned. The half life is about five years. *Cæsium* (^{137}Cs) is an alternative to cobalt

Gold (^{198}Au) This is prepared as a colloidal suspension and has been found to be of considerable use in the treatment of malignant effusions in the pleural and peritoneal cavities. The effusion is aspirated and about 100 millicuries (mc.) of radioactive gold in a quantity of saline is instilled The patient is tilted into different positions in order to disperse the solution within the cavity Effusions sometimes dry up and peritoneal deposits, if small and multiple, may regress completely The half life is two and a half days and both β- and γ-rays are emitted Gold may also be used as a substitute for radon seeds in the form of platinum covered wire This has a very small gauge and if cut into lengths of 2 mm it may be conveniently implanted into deep tissues.

Iodine (^{131}I) Radioactive iodine is much used in the diagnosis and treatment of thyroid diseases. In general, the thyrotoxic gland absorbs iodine readily while most carcinomata do not. Hence in both the investigation and treatment of thyrotoxicosis the dose must be smaller than with neoplasms The tracer doses used in toxic goitre and suspected cancer are about 10 and 100 microcuries (μc.) respectively while the therapeutic doses are of the order of 5 to 250 millicuries (mc.) Radio-iodine is given by mouth. A comparatively small number of thyroid growths take up

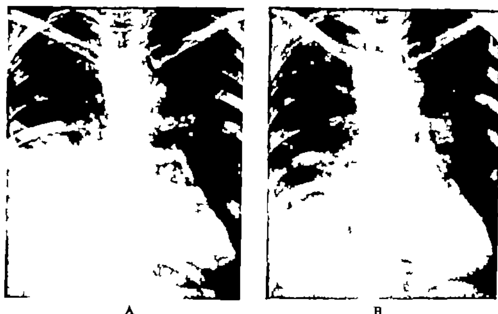


FIG. 7 4 MALIGNANT PLEURAL EFFUSION SECONDARY TO CARCINOMA OF THE BREAST
A. Before aspiration and treatment with radioactive colloidal gold.
B. Three and a half years later

iodine but one of the outstanding advantages of this form of treatment is that metastases may be treated when no other method is possible The thyroid gland itself has first call on iodine and therefore the gland must be destroyed surgically or by radiation before the metastases can be expected to take up the radioactive iodine It has a half-life of eight days and emits both β- and γ-rays

Phosphorus (^{32}P) This is usually combined as sodium phosphate. It is

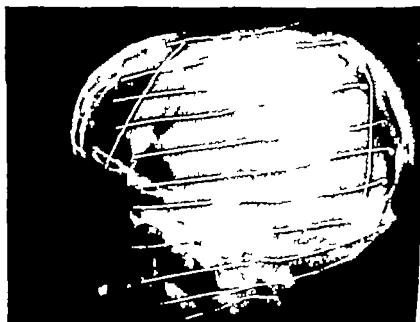


FIG. 7 5 TANTALUM WIRE IMPLANT FOR A LARGE FIBROSARCOMA OF THE SCALP

a pure β-ray emitter with a half life of fourteen days Small doses 5 to 10 mc intravenously are of great value in the treatment of polycythæmia vera Leukæmia and other reticulo-endothelial diseases have been treated with less success Radioactive phosphorus is also suitable for inclusion in surface applicators in the treatment of superficial lesions Tracer doses may be used in the localization of brain tumours.

Sodium (^{24}Na) and *Bromine* (^{82}Br) These isotopes have in common a rather short half life fifteen and thirty five hours respectively They both emit β- and γ-rays This makes them suitable for intracavitary use Carcinoma of the bladder for instance may be treated in this fashion A bag is passed through the urethra and distended with the radioactive solution which is then withdrawn after an appropriate interval of time has elapsed

Tantalum (^{182}Ta) The half life is about four months β- and γ-rays are emitted It is suitable for use as platinum covered wire which may be used for surface applicators or interstitial implantation Some encouraging results have followed its use in carcinoma of the bladder

Circulatory Studies Phosphorus and chromium (^{51}Cr) can be used for labelling red cells, iodine will combine with plasma proteins for the measurement of blood flow circulation of ascitic fluid etc., while the rate of clearance of injected sodium may give information as to the rate of blood flow in portal hypertension.

Endocrine Therapy It has been known for many years that some malignant tumours are hormone-dependent that is to say they appear to require a supply of a particular hormone in order to thrive Carcinoma of the breast and carcinoma of the prostate are the best known examples though not by any means all growths of these glands seem to be dependent upon hormonal influence

Cancer of the Breast It is sixty years since Beatson of Glasgow performed a bilateral oophorectomy upon a patient with advanced cancer of the breast. Such astonishing improvement occurred that a wave of optimism and a harvest of ovaries resulted That the operation was often ineffective and never permanent, together with the fact that spontaneous regression of growths sometimes occurred at the menopause led people to suppose that it was the menopause which was the important factor And since this could also be achieved by irradiation operation tended to be put aside as a method of treatment.

A substance normally occurring in the body œstrone, can cause cancer in the breasts of male mice and it is also true that the administration of male hormone to female mice can prevent the development of cancer Thus was born the theory of antagonistic growth substances and the basis of treatment of cancer either by deprivation of a hormone or by the substitution of an antagonistic hormone. The position can be expressed very simply thus if castration (which equals withdrawal of œstrogens) can prevent cancer arising or alternatively cause its regression when it has arisen, then administration of androgens (or œstrogen antagonization) might well have the same sort of effect

The ability to detect œstrogens in the urine of women and the discovery that not even oophorectomy let alone ovarian irradiation, invariably abolished their excretion pointed to the adrenal cortex as a further source. Hence bilateral adrenalectomy an operation first proposed and first practised by Huggins. The effects of this operation, though often striking in so

far as the relief of pain and regression of metastases is concerned are completely unpredictable and there seems little doubt that a cancer which has been hormone-dependent may later become hormone-independent. A factor of hypophyseal origin appears to exist and removal or destruction of the anterior lobe of this gland is often beneficial.

No tests yet exist which will indicate which patients are likely to derive benefit from such operations as these But it is hoped that bioassay of the urinary ketosteroids and gonadotrophins may be of help The state of the vaginal epithelium as shown in a vaginal smear is also an indication of *œstrogen activity*



FIG. 7 6. RECURRENT CARCINOMA OF THE BREAST TREATED BY ANDROGENS.
A. Before treatment. B Six months later

A further account of the endocrine treatment of carcinoma of the breast will be found in the chapter dealing with this disease.

Cancer of the Prostate. The continued growth of this tumour depends upon the secretion of androgens and, of course, the main source of these is the testes. Bilateral orchidectomy therefore can be expected to improve the condition, though as a first line of treatment stilbœstrol is usually given by mouth When this has ceased to control the disease subcapsular orchidectomy is done with or without bilateral adrenalectomy

Other Hormones. Cortisone and corticotrophin (ACTH) may have a temporary effect upon some malignant conditions. In the late stages of lymphosarcoma and Hodgkin's disease the general condition may benefit and bone-marrow function improve In the leukæmias treatment has been disappointing.

Thyroid hormone occasionally seems to act as an anti-carcinogen and it has been suggested that thyroxine should be given when the hormone balance between the various endocrine glands has been upset by excision of any one of them.

Thyroid hormone given by mouth as dried thyroid or sodium l thyroxine has a real place in the treatment of thyroid cancer It supresses the secretion of thyroid stimulating hormone (TSH) by the anterior pituitary and may arrest the spread and occasionally cause retrogression of metastases from well differentiated thyroid cancer especially when such metastases are in the lungs.

Chemotherapy In distinction to the administration of naturally occurring or synthetic hormones the treatment of cancer by cytotoxins requires consideration The ideal would be chemicals with selective toxicity for tumour cells only leaving those of the host undamaged But this ideal is not yet in sight It is said that over ten thousand compounds have been tested but only a very few have been shown to do more than prolong life for a brief span Rapidly dividing cells are those most readily effected Hence the severe anæmia and leucopenia which may follow administration The toxic dose of many of these compounds is very close to the therapeutic dose a fact of little importance in experimental work but of great moment in the treatment of patients The following have been used with comparative success mostly in malignant disorders of the blood forming and reticulo-endothelial tissues

The *Nitrogen-mustard group* (HN_2). These are much used in the treatment of the chronic leukæmias Hodgkin s disease and disseminated lympho-sarcoma The only other neoplasm which has responded with any regularity to this treatment is bronchogenic carcinoma though relief of symptoms is short lived Nitrogen mustard must be given in an intravenous drip the quantity used being about 0 5 mg. per kg. body weight. Triethylene melamine or T E.M has the advantage that it may be given by mouth. Another member of this group which is also administered orally is chlorambucil which is of use in cases of reticulosarcoma and lymphosarcoma

Folic Acid Antagonists Examples such as asteropterin and aminopterin have been used for many different sorts of neoplasm but they are very toxic and the results have been disappointing.

Urethane This is of proved value in chronic myeloid leukæmia The total white cell count falls, myeloblasts disappear and the red cells and plate lets increase The spleen shrinks Urethane is given by mouth in doses of 2 to 4 g. daily

Myleran This compound is chemically unrelated to the foregoing but is also of value in myeloid leukæmia. It appears to have a selective action in depressing granulocyte formation only in the bone marrow

The Advanced Case

Palliative treatment tends to be neglected but this is an aspect of medicine which very much concerns the family doctor Not all malignant disease terminates painfully but it is unfortunately true that in a high proportion of cases it is either pain or the effects of obstruction and infection which the doctor is called upon to relieve Emergency surgical operations such as colostomy or tracheostomy may be needed to save life but in addition purely palliative operations may be justifiable in order simply to remove a tumour which is causing great suffering Such are pelvic evisceration for advanced cancer of the female genital tract, œsophago-jejunostomy for "inoperable" carcinoma of the œsophagus or amputation of a limb for osteogenic sarcoma when it is already known that pulmonary metastases

exist. Palliative radiotherapy is also a useful weapon and, as has been stated in certain neoplasms hormones or synthetic cytotoxins may be of assistance.

Intractable Pain. *Treatment by Drugs* Morphine and its derivatives are the most effective agents. A mixture containing aspirin, phenacetin and caffeine, together with Nepenthe, 5–20 min. to ½ oz. (0·3–1·3 ml. to 15 ml.) is of benefit to many sufferers. In the terminal stages of the disease injections of morphine gr ¼–½ (16 to 30 mg.) together with large doses of barbiturates may be necessary. The addition of cocaine removes some of the depressant action of morphine and a suitable mixture is: morphine gr ¼ (16 mg.), cocaine gr ⅙ (10 mg.), gin 1 fl. dr. (4 ml.), honey 1 fl. dr. (4 ml.). Drugs of the chlorpromazine series may be found of use in the treatment of nausea. Many other ataractic or tranquillizing drugs are also in use.

Interruption of Nerve Pathways. This, the other main method of treating severe pain, may be achieved at any point between the periphery and the central nervous system. It may be designed to be temporary or permanent and, if the latter, the destruction of nerves may be by injection or division. For pain referred to the ear by infiltrating cervical growths division or injection of the great auricular nerve is possible. A presacral neurectomy may be of benefit for pelvic pain. Division of the spinothalamic tracts is sometimes undertaken and pre-frontal leucotomy seems to abolish the appreciation of painful stimuli.

A comparatively simple and successful method of treatment is the intrathecal injection of agents such as absolute alcohol or phenol. This aims at the selective destruction of the posterior root ganglia and clearly depends for success upon the positioning of the patient with regard to the specific gravity of the fluid used. Thus alcohol floats upwards while phenol, if incorporated in glycerin 1 in 20, sinks in the cerebrospinal fluid. The method may be used at any level in the cord. Epidural injections of procaine and other analgesics are also used for pelvic and lower limb pain.

The surgical relief of intractable pain is considered in greater detail in Chapter 26.

Chapter 8

THE SKIN

Overgrowth and Ulceration

The skin being the most extensive organ in the body it is not surprising that it is the site of a wide variety of lesions congenital inflammatory and neoplastic In addition many are due to various physical agents which may cause trauma In this chapter only those conditions which usually require the attention of a surgeon will be considered

Keloid This consists of an overgrowth of the connective tissue developing in scars in certain individuals who have a predisposition to the condition It is seen most commonly in coloured people but also may occur in pregnancy and is especially prone to develop in young children after scalds or burns or after operations for the removal of tuberculous cervical lymph nodes (Fig 3 9) The scar becomes heaped up red and may be extremely tender to the touch If excised it frequently recurs, but if subjected to small doses of X rays during its early stages it can often be arrested

Verruca (Wart). These are caused by a papillary overgrowth of the skin appearing as a horny projection typically on the hands or soles of the feet where they are often multiple. The surface may be smooth or filiform and thus tends to accumulate dirt. It appears likely that they are due to a virus as they appear in crops and may produce epidemics in schools or families. Since they usually disappear spontaneously treatment may not be called for but where it is necessary to remove them, they are best treated by the use of caustics such as carbon dioxide snow glacial acetic acid or painting with mercury biniodide or 10 per cent podophyllin in oil. Alternatively they may be removed with a sharp spoon and the oozing wound touched with silver nitrate.

Plantar Wart This is a special variety of wart It commonly occurs over the pressure areas of the foot and is characterized by intense pain induration and slow progression It resembles the ordinary verruca, but is thrust back into the depths of the skin from where it can be removed by sharp dissection without resort to analgesia In children, in whom these warts may be multiple they are best treated by the prolonged application of adhesive plaster containing 40 per cent of salicylic acid. They frequently occur as the result of infection of the feet in swimming baths and therefore proper footwear should be worn where such an epidemic occurs.

Corn. Corns may be hard or soft the former being much the commoner

Hard Corns These usually occur on the little toe over the head of the metatarsal of the hallux and over the heads of the first phalanges of the other toes where there is any tendency to hammer toe They form more or less conical swellings with a dark, dry central plug and can be very painful If infection occurs, suppuration leads to intense pain and the patient is crippled

Treatment consists, first of all in preventing the formation of corns by

proper orthopædic care to the feet and the wearing of shoes or boots which do not rub the prominent areas When a corn does occur it should be pared with a knife after softening by immersing the foot in hot water Salicylic acid adhesive plaster (40 per cent.) will also soften and remove some corns Considerable comfort is given if a ring of plaster is placed around the lesion so as to relieve pressure over the centre of the corn.

Soft Corns These occur between the toes and, owing to the presence of sweat, the overlying skin is white and sodden. The lesion is a particularly painful one which does not appear to be associated with pressure. Treatment consists in removing the thickened skin after the use of salicylic acid preparations and great care should be taken that the removal is not too thorough as infection in this area is difficult to treat. This is particularly the case in diabetics who should always have their feet regularly treated by a chiropodist.

Perforating Ulcer This occurs on some part of the sole of the foot (Fig. 8 1) and progresses until deeper structures including bones and



FIG. 8 1 PERFORATING ULCER OF THE SOLE OF THE FOOT

joints are involved. It is usually due to two main factors anæsthesia of the foot and recurrent trauma. Thus it is most commonly seen in those diseases of the central nervous system or peripheral nerves affecting cutaneous sensation namely tabes dorsalis, syringomyelia, spina bifida, peripheral neuritis and leprosy For this reason, when a perforating ulcer is seen, a careful examination of the central nervous system should always be made including skiagrams of the spine and also of the affected foot since the infection may have already reached the bone. Most perforating ulcers can be prevented by proper attention to the feet, but once established adequate drainage is necessary This consists in curetting the track and removing any sequestra when they are present. Where a foot becomes disorganized by sepsis as a result of a perforating ulcer amputation may be desirable.

Chilblain. This condition, otherwise known as pernio is mentioned here as it leads to painful red swellings of the fingers, toes, ears or feet. The condition is most commonly seen in young people especially those with poor peripheral circulation who suffer from cold feet and hands Prevention is better than cure and should take the form of adequate warm dry

clothing The local application of ointments is useful in so far as the friction necessary in applying them induces a local dilatation of the blood vessels Other applications which induce local hyperæmia have been suggested but usually only enjoy popularity for a short while

Benign Tumours

Pigmented Nævus. Abnormalities in the distribution of pigment can occur to almost any degree from small golden freckles to gross black and hairy lesions involving large areas of the skin surface

Mole The commonest type of nævus which sometimes calls for treatment is the mole It may be either flat and pigmented or raised and nodular with excessive pigment hair follicles and sebaceous glands Moles tend to become more obvious with age The treatment of either type is preferably excision with careful suture of the defect rather than destruction by diathermy or freezing which inevitably leads to scarring. When the lesion is large its removal will create a defect needing closure by skin grafting. On rare occasions abnormalities in the distribution of pigment and hair occur over large areas In the untreated state these tend to become more heavily pigmented and to show increasing keratosis of the surface with increasing years, but there is nothing to suggest that they are unduly prone to develop malignant changes Their removal often presents difficult problems of repair

The possibility of neoplastic change in a pigmented lesion is one which must always be remembered although it constitutes a very small risk indeed The type of lesion in which melanomatous metaplasia can occur is not clearly defined but small flat pigmented areas seem more frequently to be offenders than do the large intradermal lesions. Pigmented nodules on the soles of the feet and palms of the hands are especially prone to malignancy and these would appear to be the ones which might justify prophylactic removal. The indications for excision of a mole are changes in area especially when the pigment appears to " spill " into the surrounding tissues, rapidly increasing pigmentation and bleeding or ulceration

Hæmangioma. Three main types of abnormality of blood vessels are encountered in or near the skin. While all of them show histological variations in all the contained blood vessels both large and small it is convenient to subdivide these lesions according to the type of vessel most affected in each case

Capillary Hæmangioma The skin of the affected area is pink but its texture and contour remain normal or very nearly so The distribution of hair is normal A faint angioma of this type is often seen on the nape of the neck in the newborn the so-called " stork " mark The abnormality is essentially an increase in the capillary bed in the dermal and subdermal areas and the colour is transmitted through an otherwise normal skin There is a marked tendency to spontaneous cure The fading which occurs may be complete, though usually some scarring remains

In the past the treatment of capillary hæmangiomata has usually been by means of some form of radiation therapy such as small doses of superficial X rays, application of thorium-X paste or a radium plaque. With the present knowledge that irradiation of the skin, especially in young patients, may lead to atrophic changes which are subsequently particularly prone to the development of malignancy this type of treatment ought never to be used

The time interval between treatment and the onset of malignant change may be of the order of twenty or thirty years and therefore it is particularly undesirable that such therapy be used in infants. On the whole, surgical treatment is rarely called for in these lesions since they are usually not greatly disfiguring. But when this is so the only effective treatment is excision of the whole affected area and replacement with skin cover Often a simple measure, such as the application of cosmetic make up produces the desired result and this is usually to be preferred.

Mixed Capillary and Cavernous Hæmangioma The affected area often appears at birth as a minute red mark which within the next few months, increases rapidly in size to become bright red and well raised above the surrounding surface the so-called "strawberry birthmark (Fig. 8 2)



FIG 8 2. MIXED CAPILLARY AND CAVERNOUS HÆMANGIOMA.

Pressure deflates the lump making the colour a little paler but as soon as the pressure is released the recovery of contour and colour is almost immediate. The natural tendency of this condition is towards spontaneous cure during the first five or six years of life It is believed that the reason for this resolution is thrombosis of the vessels but it is remarkable that the colour and texture of the residual scar is so good that it may often be indistinguishable from normal skin.

When lesions of this variety are situated in areas exposed to trauma as around the waist or on the forehead, it is justifiable to excise them as this can be done neatly with little blood loss and an excellent cosmetic result. Where, however no such trauma is likely and absence of scarring is desirable, the best treatment is to wait and see. There is, however a small group of these lesions which are so large, or situated in such a site that treatment becomes imperative. For example there is a predilection of some of these tumours to occur beside the eye or in the cheek and to grow so rapidly as to displace the eye from its socket or seriously to interfere with the baby's feeding. The simplest method of treatment is the injection of 30 per cent sodium chloride solution or the use of other sclerosing agents to induce thrombosis in some of the deeper vessels. The injection of boiling water or saline has also been advocated, but this is not without risk both to patient

and surgeon In particularly intractable cases the insertion of radon seeds may be justifiable in order to arrest the progress of the tumour It should however be remembered that there is a natural tendency to spontaneous cure and the parents may always be encouraged and told that the end result is likely to be a good one so long as no drastic treatment has to be instituted

Cavernous Hæmangioma The cavernous hæmangiomata which lie beneath the skin and are not associated with a capillary condition of the overlying tissues do not show a tendency to spontaneous cure The over lying skin is raised and distorted and may feel warmer than the surrounding area The skin however is of normal colour and texture only a slight blueness being transmitted to it from the underlying vessels or blood filled spaces Pressure empties the vessel and refilling may be slower than in the mixed type of hæmangioma described above

Treatment in the very young may take the form of injection of sclerosing fluid in order to try and thrombose the blood filled spaces Usually it is better and simpler to excise the affected area and with a careful observance of hæmostasis, very little blood loss need be occasioned

Sclerosing Angioma. This rather rare tumour produces a pigmented condition of the skin which is not due to the presence of melanin The lesion is usually single and may be of any colour from blue and violet through light brown to pink or red Typically occurring on the limbs the lesion histologically is barely distinguishable from a histiocytoma and may be confused with a malignant melanoma

Molluscum Contagiosum. This condition usually produces single or small groups of discrete firm nodules in the skin of the face The nodules become umbilicated and may sometimes resemble basal-cell carcinomata. The condition is usually a self limiting one and therefore it is very important to recognize it correctly and differentiate it from malignant lesions of the skin

Molluscum Sebaceum. This is a benign condition which produces a



FIG 8 3 MOLLUSCUM SEBACEUM

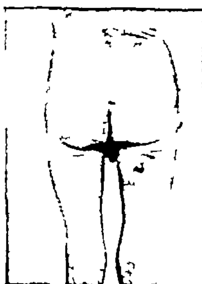


FIG. 8 4 NEUROFIBROMATOSIS OR VON RECKLINGHAUSEN'S DISEASE. The tumour in the right thigh has become a neurofibrosarcoma.

small raised tumour of the skin which closely resembles a basal-cell carcinoma. It is sometimes called a molluscum pseudocarcinomatosum. The condition is self limiting and the nodules disappear with only slight scarring. They may come and go over a period of years and there appears to be no evidence to show that they ever undergo malignant change.

Neurofibromatosis (*von Recklinghausen's Disease*). In this condition there are multiple soft tumours involving most of the peripheral nerves in the body and they are therefore seen most clearly in the limbs. They tend to grow slowly with the passage of years and can form a most unsightly condition, especially when they hang in grape-like masses all over the body. They are usually associated with irregular areas of pigmentation of a pale brown colour called "café-au-lait" spots. Treatment is called for only on cosmetic grounds when it may be necessary to remove some of the more unsightly masses through multiple incisions. A rare complication of this disease is malignant change in a nerve which produces a rapidly fatal result (*Fig. 8 4*). *Some of the other clinical features of this condition are referred* to in the orthopædic section.

Malignant Tumours

Rodent Ulcer. The commonest malignant neoplasm of the skin is the basal-cell carcinoma or rodent ulcer. This tends to occur on the exposed surfaces of the face and hands and is commoner in middle and old age. It is



FIG. 8 5. TYPICAL RODENT ULCER OF THE OUTER CANTHUS WITH A DEPRESSED CENTRAL SCAR.



FIG. 8 6. NON-ULCERATED RODENT ULCER (CYSTIC RODENT).

also more prone to occur in those with lightly pigmented skins who have been exposed to intense sunlight for a long period, as in the tropics. In these people it is almost invariably multifocal, but is fortunately of a relatively low grade of malignancy. It does not appear to occur in dark skinned races. It usually appears as a small hard nodule having a distinctive semi-translucent appearance, except for one or two telangectatic vessels on its surface. Sooner or later a small central ulcer appears which scabs over and when the scab falls off the raw surface is seen to be a little larger than previously. The process continues until the ulcerated area is too large to allow it to crust over.

Although the above describes a typical example there are many diverse

forms and the small persistent raw surface which extends slowly as a marginal lesion with apparent healing in its central area is not uncommon. Diagnosis depends upon a biopsy which should be taken from the edge of the lesion. Occasionally it is justifiable not to do this where the lesion is a tiny one and adequate facilities for X-ray therapy are available.

Treatment. Metastasis is not seen, therefore the treatment is that of the local lesion. The simplest form of therapy is that provided by a well-shielded narrow beam of X-rays or, alternatively, a small radium plaque may be used. The cosmetic result of such treatment is excellent and since in some countries these lesions are common and multiple, this form of therapy is convenient. Rodent ulcers are also capable of excision, but they must be removed with a healthy margin of skin and this may require reconstructive measures with skin grafts or flaps.

Squamous-cell Carcinoma (*Epithelioma*). This is a less common form of malignant skin lesion than the rodent ulcer, but when it occurs it presents a



FIG. 8.7. SQUAMOUS-CELL CARCINOMA OF THE HAND
The patient worked in a tar distillation factory.



FIG. 8.8. SQUAMOUS-CELL CARCINOMA OF THE LIP

greater potential danger to the patient's life. It may occur as chronic ulceration which has no tendency towards healing and it is often encountered in areas where irritation is a factor, although it is by no means confined to such sites. It can occur anywhere and is not confined to the surfaces on which a rodent ulcer may be expected. It is seen as a result of irritation due to carcinogenic substances such as tar and should therefore be remembered when examining workers from coal distillation and gas producing plants. It may occur on the scrotum of chimney-sweeps and also those whose oily clothing irritates the skin in this area, such as mule-spinners. It was in these workers that the association between carcinogenic tars and skin cancer was first described. It is, in Great Britain, a notifiable disease. It may also occur as a secondary change in any ulcer of long standing, as for example that overlying chronic osteomyelitis or varicose ulceration. In such circumstances it is referred to as a Marjolin's ulcer (Fig. 8.8). Squamous-cell carcinoma spreads both locally and distally to the regional lymph nodes and is only rarely disseminated by the blood stream.

Treatment. This consists of wide excision of the lesion. In addition

removal of the regional lymph nodes and any intervening area which appears involved should be done if practicable Problems of repair will arise, but these may often be deferred until the possibility of recurrence has been minimized by the passage of time. For example the excision of the nose and upper lip together with part of the premaxilla, may have been necessary on account of a squamous-cell carcinoma. The raw surface so created will be epithelialized by the application of a split skin graft merely as a dressing. The cut surfaces therefore are now masked only by a thin layer of skin. If there has been any doubt as to the adequacy of the excision it may be preferable to cover this defect with a prosthesis and to wait for say nine to ten months before undertaking the many stages of the definitive repair The patient will thus be enabled to lead a comparatively normal existence with a promise of ultimate restoration At the same time the margins of the original excision remain easily visible and any recurrence will be seen at the earliest moment. On the other hand too early definitive repair may mask the recurrence until it is well established and the patient will thus have the double disappointment of having his completed repair widely excised as well as the prospect of a repetition of his entire series of operative procedures

Radiotherapy offers an alternative form of treatment in many cases

Melanoma. A malignant melanoma arises in a pre-existing mole in about three-quarters of the cases and any part of the body may be affected,



FIG 8 9 MALIGNANT MELANOMA OF THE HEEL.



FIG. 8 10 MALIGNANT MELANOMA OF THE NECK.



FIG. 8 11 MALIGNANT MELANOMA OF THE VULVA.

the lower limbs trunk and genitalia being the most common Melanomata also arise in the choroid of the eye, around the mucous surfaces of the mouth, the nose and in the anal canal. It is difficult to describe the typical appearance of a melanoma since it varies so much, but any pigmented mole which begins to enlarge, in which the pigment tends to spread into the surrounding tissues, or one in which ulceration occurs should be suspected of malignant change. The sole of the foot is a common site and another variety occurs underneath the nail bed, especially in the toes. It is not justifiable to perform a biopsy in order to establish the diagnosis since there is strong evidence that this may cause spread. Biopsy therefore should always be an excision biopsy Pigmented moles arising before puberty do not undergo malignant change

Treatment These tumours are highly malignant and treatment is a

sorry business for it is unlikely that many patients will be cured However the principle is to remove the lesion with a wide margin of apparently healthy surrounding skin equal approximately to half the diameter of the pigmented area In addition a prophylactic dissection of the regional lymph nodes should be carried out except in the case of the lower limb where if the excision is properly done there is a likelihood of lymphorrhœa from the wound and a swollen limb However if there are palpable lymph nodes in the groin these should be excised by block dissection Melanomata are relatively insensitive to X rays but this form of treatment has sometimes been used in palliation



FIG 8 12. FIBROLIPOSARCOMA OF THE SKIN OF THE LEG.

Other Malignant Tumours. The dermis and subcutaneous tissues may be the seat of sarcomatous neoplasms. Liposarcoma fibrosarcoma and angiosarcoma are all described.

Angiosarcoma This rare disease may be seen at any age and gives rise to solid tumours which may be single or multiple in the skin The growth is often rapid and the tumours are painful and bleed Treatment is best carried out by radiotherapy but spread to the lungs usually causes a fatal termination A special variety of angiosarcoma, called Kaposi's disease or hæmangiosarcoma causes multiple small reddish brown nodular lesions, typically in the extremities. The nodules are not painful and can usually be controlled by radiotherapy For this reason the prognosis is not bad and many patients survive for years with suitable courses of treatment.

The Sebaceous Glands

Sebaceous Cysts. These may occur on any part of the body surface but show a special predilection for the scalp They are due to the obstruction of the duct of a sebaceous gland and this results in a rounded swelling, firm and elastic to the touch movable over deeper structures, but always attached at one spot to the skin On careful examination the obstructed mouth of a sebaceous follicle can usually be seen and occasionally some of the contents of the sac can be squeezed out through this opening or punctum. The cyst

wall is formed by several layers of epithelium surrounded by dense scar tissue and if exposed to constant irritation or pressure as when situated on the back, it becomes very firmly adherent to the surrounding parts. The material within a sebaceous cyst is of a cheese like or pultaceous consistence. It has a distinctive and rather disagreeable stale odour is yellowish-white in colour and is composed of fatty and granular débris together with epithelial cells and cholesterin crystals. Untreated cysts may reach a great size and occasionally the walls are calcified

Differential diagnosis is from dermoid cysts and lipomata A dermoid cyst is congenital in origin limited to certain parts of the body and rarely directly attached to the skin A lipoma is of softer consistence, rounded and typically lobular moreover there is no punctum or fixation to the skin The treatment of sebaceous cysts is removal which is very easily carried out by injecting the skin with local analgesic and then making a small incision and shelling out the cyst together with its contents. Where sepsis is present the abscess should be drained and the patient told that excision will be required at a later date

Sebaceous Adenoma. True adenomata of sebaceous glands are rare, but a common congenital abnormality consists of an agglomeration of sebaceous glands into a small mass. This is raised above the surface of the surrounding skin and is slightly pigmented and greasy It becomes progressively more heavily pigmented and nodular It is usually capable of excision without creating a defect of sufficient size to require any complicated procedure for its repair

Rhinophyma This is a condition caused by the hypertrophy of sebaceous tissues within the skin and is usually confined to the nose (Fig. 31 3) and adjacent cheek, although it may rarely involve the ears Treatment is desirable because of the special implications of the condition though there is no evidence to suggest that it is in any way due or related to alcoholism. The most satisfactory treatment consists in paring the affected area down to the correct contour The regeneration of the skin occurs rapidly from the remnants of the sebaceous glands in the area, but an accurate appraisal of the depth of the excision is essential.

The Nails

Paronychia. Sepsis around the nail and nail fold is frequently occupational in origin and found in those people exposed to trauma and whose skins are often sodden with water The signs are those of an inflammatory condition and treatment should include local heat therapy and drainage of pus when it forms. It should be remembered that the nail itself acts as a foreign body and may require removal. Should the condition become chronic, complete rather than partial removal of the nail gives a better result

Ingrowing Toenails. This is an ulcerated condition of the softer parts projecting over the side of one of the toenails, usually that of the hallux, due to pressure from badly fitting footwear careless manicuring or neglect. In the early stages simple measures usually suffice The nail should be trimmed properly and the overhanging skin edge pressed back with a tiny *pledget of wool* For the more advanced case cure can be effected by excising an oval portion of skin from the side of the toe, together with an ellipse of nail including a small portion of the nail-bed Skin and nail can be approximated by one or two sutures passed through and through with a strong

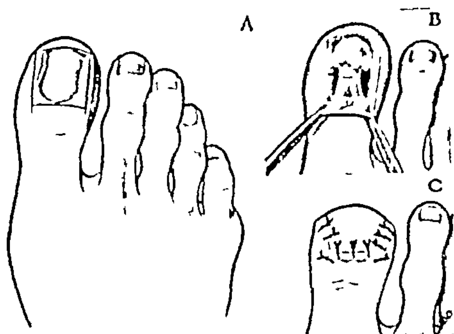


FIG. 8 13 OPERATION FOR INGROWING TOENAIL BY REMOVAL OF THE NAIL BED AND A PORTION OF THE TERMINAL PHALANX

cutting edge needle However when the condition is recurrent or severe the only course to adopt is removal of the complete nail and its bed amputation of the distal half of the terminal phalanx and mobilization of the soft tissues may be desirable to cover the raw area The final result is a little unsightly but guarantees a cure



FIG. 8 14. ONYCHOGRYPHOSIS.

Onychogryphosis. This is a hypertrophic condition of the nails, usually affecting the great toe, in which the nail is distorted and bent so that it resembles a ram s horn. It may be seen in children as well as adults and the cause is not always apparent Often it follows trauma, such as dropping a heavy object on the toe. The dense horny nail can be trimmed with bone

cutters, but will regrow in time. Cure consists of excising the complete nail and nail-bed.

Subungual Conditions. A number of unrelated pathological conditions may be found arising beneath a nail where they may give rise to particular symptoms.

Hæmatoma Trauma may produce bleeding from the capillaries of the nail bed Since there is little room for expansion the condition gives rise to considerable pain. Treatment consists in incising the nail longitudinally so as to allow the clot to escape, or making a hole with a red hot needle.

Exostosis An osteoma arising from the terminal phalanx is not uncommon It produces distortion of the nail and its presence is confirmed by a skiagram. Removal may be necessary

Melanoma. The nail-bed is sometimes the site of origin of a malignant melanoma which is seen as a dusky spot beneath the nail. The hallux is particularly affected If the diagnosis is confirmed histologically by an excision biopsy amputation of the toe should be done A close watch should be kept on the regional lymph nodes for evidence of metastasis.

Glomus Tumour A glomangioma is a tumour of a cutaneous glomus, *i.e* a specialized arteriovenous anastomosis surrounded by large pale cells (glomus cells) between which is an abundant network of nerves. It occurs most commonly in the extremities particularly in the nail-bed It is slow growing, encapsulated, blue or red in colour and may be symptomless or give rise to severe attacks of burning pain Removal effects a complete cure

Chapter 9

THE LYMPHATIC SYSTEM

Lymphangitis

The lymphatic system is made up of lymphatic vessels and lymph nodes which are widely distributed throughout the body. The lymph nodes tend to be aggregated in certain sites such as the axilla groin and cervical regions. The lymph channels unite as they pass towards the centre of the body and many of them eventually discharge into the thoracic duct. This may be injured in operations within the chest or at the root of the neck with a resulting lymphatic fistula. Lymph nodes are enlarged in a great variety of inflammatory conditions and malignant diseases and therefore reference will have to be made to other sections of the book where necessary.

Acute Lymphangitis. The commonest cause of acute lymphangitis is the hæmolytic streptococcus, but almost any organism may be responsible. The lymphatic channels become inflamed tender and if near the surface of the skin may show as long red streaks. A typical example follows a whitlow from which infection may be seen spreading along the forearm and ending in the epitrochlear nodes at the elbow or in the axilla. Treatment should be directed to the cause but the local part should be rested and suitable antibiotics administered.

Chronic Lymphangitis. This results either as the sequel of an acute attack or may be met with as a distinct condition. It is frequently seen as a result of venereal disease, *e.g.* the dorsal lymphatics of the penis becoming enlarged, hard and cord like especially in primary syphilis. In this condition there is an associated œdema of the prepuce and enlargement of the inguinal lymph nodes. The condition responds to antiluetic treatment. Similarly in tuberculous epididymo-orchitis, the lymphatics of the spermatic cord may be thickened and present a characteristic beaded feeling on palpation. A chronic relapsing lymphangitis may be seen complicating fissures around the anterior nares and lips. This is particularly resistant to treatment.

Erysipelas. This condition, which is as old as medical history appears to have changed its character during the present century. A hundred years ago it was a dreaded condition but to-day it is unusual to see a patient with a severe attack although in infancy and old age it can still occasionally endanger life. It is caused by the entry of hæmolytic streptococci into the lymphatics of the skin causing a thickening with a characteristic fiery red colour and tiny vesicles. The edge of the lesion is felt rather than seen and the patient may be toxic and have a high temperature. Treatment consists of administering a sulphonamide by mouth such as Sulphatriad 1 g. four times a day or injecting penicillin, half a million units per day and insisting that the patient drinks copious fluids. On this régime the condition gradually subsides but the discomfort of the local condition can be relieved by the

application of the time honoured medication of ichthyol 20 per cent in glycerin as a paint An attack of erysipelas does not confer lasting immunity on the contrary the patient especially if elderly appears to become more prone to further attacks. Therefore any fissures round the nose, mouth or ears should be most carefully treated and prevented from becoming infected.

Inflammatory Lymphadenopathy

Most diseases involving the lymph nodes lead to their enlargement. The term lymphadenopathy includes both inflammation and many varieties of malignant disease

Acute Lymphadenitis. In this condition the regional lymph nodes are involved in an acute inflammatory process, organisms reaching them from some area in the vicinity although by the time they are manifest, the original lesion may have healed. Not all inflammatory conditions lead to lymphadenitis and it at first appears surprising that such conditions as a carbuncle or spreading gangrene produce no lymphadenopathy this is probably accounted for by thrombosis of the capillaries accompanying the lymphatics

The affected lymph nodes are moderately large, acutely tender and at first mobile. Later inflammation beyond the capsule of the node (periadenitis) produces fixation and induration of the surrounding tissues.

Treatment consists in dealing with the primary infected focus in the first place This will mean letting out pus where it is present and administering the appropriate antibiotics The enlarged lymph nodes may suppurate and pus should then be drained by an incision immediately over the swelling. A knowledge of the local anatomy is necessary if this is to be done neatly and without injury to nearby structures, such as the cervicofacial or spinal accessory nerves in the neck.

Non-specific Chronic Lymphadenitis. This is seen where there is low grade sepsis at the periphery and the lymph nodes are continuously receiving organisms There appears to be a tendency to arrest of the infection in the nodes so that suppuration does not take place, but there is a chronic firm tender swelling. This is typically seen in the cervical adenitis affecting the jugulodigastric node as a result of recurrent tonsillitis. Its differentiation from a tuberculous infection may be very difficult.

Syphilitic Lymphadenitis. The lymph nodes may be affected in several ways in the course of syphilis

The primary chancre is usually associated with grossly enlarged regional lymph nodes, especially in the case of extragenital chancres.

In the secondary stage of syphilis there is usually a generalized lymphadenopathy throughout the body but the lymph nodes are not usually particularly large and have to be searched for Involvement of the occipital and epitrochlear nodes is characteristic of the disease.

In the tertiary stage a gummatous process may affect the lymph nodes but a lymphadenitis secondary to a gumma of the skin is a more common feature.

Tuberculous Lymphadenitis. This occurs most commonly in children but age is no bar and occasionally in old people the condition may be confused with secondary malignant nodes The enlarged lymph nodes are

secondary to a tuberculous process elsewhere and the infection has usually reached them *via* the lymphatics. Typical examples are the cervical adenopathy seen following a tonsillar or adenoidal infection (Fig. 9.1), the mediastinal lymphadenopathy in pulmonary tuberculosis and mesenteric adenitis in disease of the small bowel. Occasionally the primary focus cannot be found. The condition is becoming much less common in Britain owing to the pasteurization of milk and the increased number of attested herds having largely eliminated bovine tuberculosis.

Tuberculous cervical lymphadenitis forms a rather special condition and this is described in Chapter 33. The regional lymph nodes may be involved when the primary infection is in bone and for this reason a biopsy of an inguinal lymph node may be a useful diagnostic measure when tuberculous disease of the knee joint is suspected.



FIG. 9.1. TUBERCULOUS LYMPHADENITIS IN A CHILD.



FIG. 9.2. TUBERCULOUS LYMPHADENITIS ULCERATING THROUGH THE SKIN OF THE NECK IN AN ADULT.

The earliest stage of the disease consists in a fleshy enlargement of the nodes which cannot be distinguished from simple hyperplasia. The nodes may be enlarged to many times their normal size while on section they look pink and are of firm consistence. Microscopically there is an increase in the germinal centres and a sinus catarrh. When tuberculous infection is established, the characteristic foci made up of giant cells surrounded by endothelioid cells can be seen. This is followed by caseation which may occur in multiple foci scattered throughout the node. This material may either be discharged through a sinus (Fig. 9.2) or gradually shrink to form a firm hard mass which typically undergoes calcification. It is common to see calcified mesenteric and mediastinal lymph nodes in skiagrams of adult patients, but calcified lymph nodes in the neck are rather less frequent.

Treatment. The ideal to be attained is its prevention. A clean and tubercle-free supply of milk should be available to everyone and those patients who have an open tuberculous focus ought to be segregated from the rest of the population.

Treatment of the established condition is mainly conservative. Rest is important and immobilization of the local area is used where possible. The diet is a generous one containing plenty of tubercle free milk, eggs, cod-liver oil and fresh fruit and vegetables. Open air treatment and sunlight in moderate amounts are helpful, the whole régime being similar to that pro-

Tumours of Lymphatics

Tumours of lymph vessels, which are called *lymphangiomata* are frequently also associated with dilatation of the lymphatic vessels, a condition called *lymphangiectasis* There is no sharp dividing line between the two conditions and they frequently develop simultaneously

Capillary Lymphangioma. This is usually congenital in origin, but frequently increases in size during the first year of life When developing in the skin it may be termed a lymphatic nævus and shows as a yellowish brown patch which, on closer inspection through a magnifying glass, reveals numerous pin point vesicles. This form of lymphangioma is often associated with a lipomatous mass. Treatment is by excision and when the condition is extensive skin grafts will be required to cover the defect.

Cavernous Lymphangioma. In this tumour there are cystic spaces filled with lymph and there may also be an overlying capillary lymphangioma of the skin There is no well defined border and therefore excision is difficult. However this remains the best form of treatment because any kind of irradiation is inadvisable if the patients are young, since it is not safe to risk the possibility of neoplastic changes in the tissues later



FIG. 9 4 CYSTIC HYGROMA IN AN INFANT

Cystic Hygroma. This is a variety of cavernous lymphangioma which is typically seen in the neck, especially in the lateral and posterior aspects. It is usually present at birth, but may grow rapidly for a short while thereafter (Fig. 9 4). It appears as a very soft lax swelling covered by normal skin which is not tender and which transilluminates more brilliantly than any other swelling in the body It has been said to arise from the lymphatic endothelium of the jugular sac. Treatment of this condition is difficult for the fluid spaces are small and therefore any kind of injection therapy is likely to have only a localized effect. Excision offers the best means of dealing with the condition, but skin grafts may be required and it is difficult to prevent a certain amount of scarring.

Malignant Lymphadenopathy

Many malignant conditions involve the lymph nodes of the body especially those of the cervical region and the correct diagnosis of swellings in the neck is one of the most difficult in the whole of clinical surgery Some

of the more important conditions which may affect lymph nodes are listed below but reference may be made to many sections in the book for further information and particularly the chapter devoted to diseases of the neck

Hodgkin's Disease or Lymphadenoma This condition is one of a large group referred to as the lymphomas or reticulo-endothelioses The ætiology is unknown and several types exist from that which is rapidly fatal to a relatively benign and fibrous variety sometimes referred to as paragranuloma Clinically there is a progressive enlargement of the lymph nodes throughout the body especially those in the neck splenomegaly hepatomegaly and enlargement of many other organs The lymph nodes have a distinctive rubbery feel and remain discreet and mobile to a late stage in the disease Deposits of similar histology may occur in the skin and in the alimentary canal especially the stomach *Diagnosis is made by histological examination of a lymph node removed at biopsy*

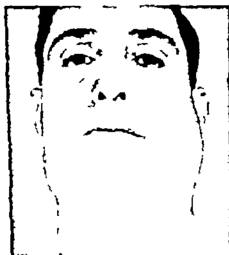


FIG. 9 5 LYMPHADENOMA.



FIG 9 6. LYMPHOSARCOMA.

The patient is usually a young adult and there is often a history of lack of energy and an intermittent pyrexia, the so-called Pel Ebstein phenomenon There is often anæmia and there may be an increase in the number of eosinophils in other respects the blood count is normal. The enlargement of the lymph nodes causes pressure on many structures, typical examples are the bull-neck and superior vena-caval syndrome due to enlargement in the upper mediastinum

Treatment This is undertaken only after a lymph node has been removed and the diagnosis confirmed. High voltage X-ray therapy often causes great reduction in the size of the lymph nodes and may prolong life for a considerable period It is not usually possible to irradiate the same area more than once and recurrent nodes are less radio-sensitive. Recourse is then had to therapy with the nitrogen mustard group of drugs and a great variety of other chemical substances toxic to growing cells. ThioTEPA is a typical example of these. In the rare form of paragranuloma in which the nodes are much firmer and mobile wide excision may lead to apparent cure.

The Reticuloses. A great number of conditions cause enlargement of

lymph nodes throughout the body as a result of involvement of the reticulo-endothelial system They vary from the rather rapidly developing types, such as Letterer-Siwe disease and the histiocytic medullary reticulosis of Scott and Robb-Smith to the much more slowly progressive varieties, such as those associated with the names of Hand-Schüller-Christian and eosinophilic granuloma.

Brill's Disease This condition, otherwise known as Brill-Symmers's disease or lymphoid follicular reticulosis, affects patients past middle age. The lymph nodes are enlarged and in addition there is usually splenomegally Histologically the condition is distinctive with very active germinal centres in the lymphatic tissue. There is often an accompanying anæmia and some form of skin disease such as eczema or dermatitis Diagnosis is made by biopsy and the condition if uncomplicated, may permit survival for as long as ten years

The Leukæmias. There may be enlargement of nodes in both the myeloid and lymphatic forms of leukæmia. Lymphatic leukæmia is the commonest of this group and the lymph nodes may be enlarged throughout the body but tend not to reach a great size and are typically soft in consistency Treatment by means of cortisone or ACTH the anti-folic-acid agents, aminopterin and radiotherapy are all of use, but the condition is invariably fatal.

Lymphosarcoma. A sarcomatous change may take place in the reticulum of lymph nodes and lead to a rapid enlargement of them The disease tends to be seen in older patients and the masses are soft in consistence and extremely vascular Treatment is by radiotherapy to which the tumours are particularly sensitive However each course of treatment leaves the condition more refractory to the therapy and the outcome is invariably fatal.

Malignant Metastases. Carcinoma typically metastasizes to lymph nodes, though not necessarily to those in the same region of the body Thus, biopsy of a lymph node in the axilla may reveal a secondary deposit from a neoplasm in one of the abdominal organs and therefore in the absence of a tumour in the area drained by a particular group of nodes, diagnosis can only be made by removing a node and examining it histologically

Section Two

ORTHOPÆDIC SURGERY

H L C WOOD MICHAEL HARMER

Chapter 10

MUSCLES, TENDONS AND BURSÆ

Injuries of Muscles and Tendons

Contusions. Muscles are bruised as a result of blows or falls which lead to œdema or hæmorrhage with possibly some rupture of the fibres. The part becomes tender and swollen and any active contraction gives rise to pain; passive movement, however, is tolerated if the injured fibres are not thereby put on the stretch. Fomentations and rest may be needed for a few days, but massage and perhaps elastic support are subsequently necessary.

Sprains and Strains. These are due to violent effort or falls and result in the tearing or stretching of some of the fibres. Considerable pain and stiffness follow. Rest and firm pressure should be used at first, to minimize effusion or to ensure its absorption. The limb must be placed in such a position as to relax tension on the injured part and often a pad or firm bandage over the tendon at a little higher level will steady it and enable it to be used without pain. Elastic pressure, massage and the alternate application of hot and cold water will do much to ensure complete recovery.

Bowler's Arm. This condition is due to a strain of the coracobrachialis or the long head of the biceps, and often occurs after a long spell of fast bowling, manifesting itself at the end of the day when all movements of the arm appear to be painful. Absolute rest from bowling for at least two weeks is essential, during which time massage and active movements should be encouraged.

Tennis Elbow. This falls into the same category as bowler's arm. The strain may be caused by a variety of occupations: lifting weights, carrying shopping baskets or using spanners, saws or hammers. Either the flexor or extensor origin may be affected, giving pain when the appropriate muscles are contracted or stretched. Hence weakness of grip is a typical feature. Local tenderness over the epicondyle is found, the external epicondyle being commonly affected. The essential factor in treatment is rest of the arm, preferably in a sling. Local injection of 2 per cent. procaine or a suspension of hydrocortisone in saline is worth a trial. The condition tends to clear up spontaneously in weeks or months, but resistant cases may require manipulation. This consists of stretching the extensor or flexor origin under general anæsthetic.

Tennis Leg. Although unfamiliar in this country, this is a well known condition in America. The term is used to define a group of injuries characterized by slight or more serious damage to the muscles, tendons and aponeuroses forming the triceps cruris. The term also includes injuries said to be caused by a violent strain of the plantaris tendon. The player experiences a sudden, acute pain in the calf and this is followed by stiffness and swelling. A bruise may appear a few days later. Treatment consists

of rest, wearing an elastic support and having the heel of the shoe raised for a few weeks.

Rugby Wrist. This is due to a bruising of the triangular fibrocartilage which separates the lower end of the ulna from the wrist joint. It is caused by handing off with the ulna side of the hand Movements of the wrist joints are painful and restricted and treatment consists of rest on a splint Recovery may be expected within three weeks

Stenosing Tenovaginitis. This condition is described on page 178

Rupture of Muscle Sheath. This accident is occasionally met with, especially in the thigh adductors and rectus abdominis The belly of the muscle when relaxed protrudes through the opening as a hernia and gives the sensation of a fluctuating swelling. In treating this condition the limb must be kept at rest in such a position as to relax the muscular fibres and allow the rent in the fascial sheath to heal. In old-standing cases it is justifiable to expose the opening in the muscular sheath the edges of which are sutured together or if this cannot be effected a graft of fascia lata may be stitched over the defect.

Displacement of Tendons. This rarely occurs except where these structures pass through osseofibrous canals and particularly in those where the direction of action is thereby changed During some violent effort the patient feels a sudden localized pain followed by a certain amount of limitation of mobility This accident is popularly known as a " rick. In superficial parts, the displaced tendon can sometimes be distinctly felt in an abnormal position and this becomes more evident on attempting to move it. Thus the long tendon of the biceps may be dislocated from the bicipital groove various tendons about the wrist or ankle, especially that of peroneus longus, may similarly suffer

Treatment The muscle must be fully relaxed and the tendon replaced, if possible, by manipulation The parts are then immobilized for six or eight weeks by a plaster of Paris splint or strapping. If the displacement recurs, operative repair of the fibrous sheath may be advisable.

Rupture of Muscles and Tendons. This is by no means uncommon, resulting from violence of an unexpected nature Most frequently the tendon gives way at its union with the muscular belly less often the belly itself yields, while occasionally the tendon may snap or the point of bone to which it is attached may be torn off

Signs The patient experiences a sharp and severe pain at the moment of the accident as if he had been struck with a whip he may also feel or hear a snap Loss of function follows, together with a certain amount of pain swelling and bruising, which are more evident if the muscular fibres have been torn across than if the tendon alone has been lacerated On attempting to contract the affected muscle, the belly rises up as a soft, rounded fluctuating tumour (Fig. 10 1) drawn towards the uninjured attachment if the union between the tendon and belly has given way while if the lesion occurs through the tendon a distinct gap or sulcus can be felt.

Repair is established by the formation of granulation and finally of cicatricial tissue. Where a muscle is involved and the ends are much separated, a long and weak bond of union forms but when they are closely apposed, the cicatrix is short, and function correspondingly good. When a tendon has been divided or torn the connecting medium is at first attached to the sheath and if this adhesion persists, it may lead to pain and weakness.



FIG 10 1 BILATERAL RUPTURE OF THE LONG HEAD OF THE BICEPS HUMERI

It is interesting to note how rapidly this tissue becomes strong a rabbit s tendon ten days after division requires a weight of 56 lb (27 kg.) to break it.

Treatment It is essential to relax the parts fully so as to limit the separation of the divided ends and to maintain them in this position for two or three weeks Any resulting stiffness is combated by movements and massage, whilst, if need be adhesions are broken down under an anæsthetic Tendons accidentally divided in open wounds should be sutured with silk or stainless steel wire careful antiseptic precautions being adopted to prevent suppuration in the tendon sheaths. Where there has been actual loss of substance in a tendon one may be split longitudinally in such a way as to leave a thin flap attached peripherally so that the free end can be turned down and united to the other segment (Fig. 10 2A) similar flaps may be provided from each end (Fig. 10 2B) it may be possible to remedy the defect

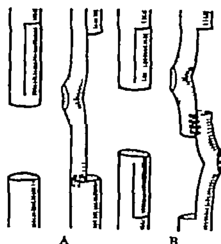


FIG 10 2. METHOD OF UNION OF A TENDON AFTER LOSS OF TISSUE. In A the flap is taken from one end only In B from both ends.

by grafting a portion of tendon from another region between the two ends. Care must be exercised to prevent opposing muscles from dragging on and stretching the new bond of union as thereby considerable functional disability may result.

Muscular bellies which have been divided longitudinally or obliquely are easily united by sutures but when the section is transverse, the stitches tend to cut out, unless the sheath can also be secured In such a case it is advisable to encircle with a ligature a bundle of muscular fibres on either side of the incision, and then tie the two threads together This must be done at several places in the cross-section

The *long tendon of the biceps* may be ruptured within the capsule of the shoulder joint. On active flexion of the elbow the belly of the muscle contracts into a rounded swelling which can be seen in the lower part of the arm (Fig. 10 1) The accident occurs in elderly men in whom the tendon has become weakened by degenerative changes in the joint. Loss of power of flexion of the elbow is surprisingly small and two weeks rest in a sling followed by active exercises will restore good function. In active subjects, however it is better to suture the proximal end of the muscle belly to the periosteum of the humerus near the lower end of the bicipital groove. The surplus length of long tendon may be excised.

Rupture of the *tendo Achillis* may result from sudden contraction of the powerful calf muscles, as in playing squash rackets or tennis, kick-starting a motor cycle, or slipping on a stair The accident is seen in those between thirty and sixty years of age who occasionally play games, rather than in those who take regular exercise The patient feels a sharp pain in the heel, sufficient to cause faintness. He is unable to stand on the ball of his foot with the heel raised from the ground A gap can be felt in the tendon and considerable swelling occurs within a few hours. These symptoms are sometimes diagnosed as being due to a rupture of the plantaris tendon, but a moment's reflection will show that such an insignificant tendon could not possibly be responsible. The tendon should be repaired by suture at the earliest opportunity Following operation, the foot is immobilized in a plaster cast in full plantar flexion for six weeks. After removal, the shoe heel is raised 1 in. (2 5 cm) and this height is gradually reduced over a period of two or three months. Active exercises to restore the strength of the calf muscles must be encouraged

The *adductor longus* may rupture in riding a horse and constitutes one form of rider's sprain

Rupture of tendons around the hand and wrist is a common complication of rheumatoid arthritis The extensor tendons are usually affected.

Rupture of the *extensor longus pollicis tendon* is an occasional complication of Colles fracture

Division of the Long Tendons of the Fingers

This is a common accident. Loss of the power of active flexion is a serious disability that of extension, less so

Flexor Tendons. These may be divided at the wrist, in the palm, or in the fingers, and the treatment depends upon the site of the injury It is most important to realize that injuries to flexor tendons may lead to serious and permanent loss of function in the hand

Tendon surgery is a major surgical procedure and successful repair can

only be the outcome of careful attention to detail under ideal surgical conditions. Repair should not be attempted in Hospital Casualty Departments or by junior staff.

In certain situations primary suture may be performed within six hours of the injury after adequate wound toilet. Later than this the wound should be regarded as potentially infected and tendon suture must be delayed until the wound has healed.

Division at the Wrist. Many tendons may be injured together with the median or ulnar nerves. After careful wound toilet and hæmostasis the tendons are sutured with stainless steel wire or thread. In the absence of infection good return of function may be expected.

Division in the Palm. The flexor tendons lie in a common synovial sheath. The sublimis or profundus tendons may be divided or both together. Digital nerves may be injured and require repair. The use of a pneumatic tourniquet is essential in order that a clear view of the field of operation may be obtained. Enlargement of the wound may be necessary for the same reason.

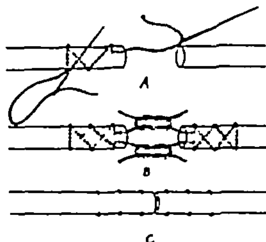


FIG. 10 3 THE TECHNIQUE OF TENDON SUTURE

The ends of the tendons are first trimmed. First one and then the other is transfixed with silk threaded into two needles. The ends of the tendon are brought into apposition, and the sutures tied. The knots lie between the ends of the tendon. A shows the method of suturing each end, and B shows diagrammatically how the knots lie. In C the appearance on completion of the operation is shown.

When both superficial and deep tendons are divided, end to end suture should be performed and the lumbrical muscle used to isolate the suture line of one tendon from the other. In some cases it may be better to suture the profundus tendon only and to remove as much of the sublimis as possible.

Division in the Finger. Here the flexor tendons lie in a fibrous sheath, which of necessity must be divided at the same level as the tendon. Adhesions at the suture line will prevent mobility of the tendon and the result of end to end suture at this level is nearly always a stiff finger.

It is better not to attempt primary suture but merely to cleanse the wound and to suture the skin. When soundly healed a formal operation may be undertaken about one month later. This will consist of the total removal of the flexor sublimis tendon and the repair of the profundus by a free graft inserted between the palm of the hand and the terminal phalanx.

It should be emphasized that surgery of this kind should be undertaken only under ideal conditions and that special training in the technique is necessary

Extensor Tendons. These have no synovial sheaths and mobility is maintained by elastic paratenon Primary suture of the tendon followed by splinting in extension for three weeks usually results in good function.

Mallet Finger (*Cricket Finger*) This is caused by a sudden blow on the tip of the finger and is a flexion injury The extensor tendon is avulsed from its attachment to the terminal phalanx or a small flake of bone is pulled off The patient is unable to extend the terminal phalanx.



Fig. 10 4 Mallet Finger.



Fig. 10 5 Plaster for Mallet Finger.

To be effective, treatment must be started at once. The terminal joint is maintained in hyperextension and the middle joint in semiflexion by a plaster splint. In this position the middle slip of the extensor aponeurosis pulls down the two lateral slips and so relaxes tension at the site of the injury The splint should be retained for six weeks. In late cases deformity may be permanent though the disability is slight. Operative repair may occasionally be indicated.

Diseases of Muscles

Myositis

Inflammation of muscles may arise in a large variety of circumstances, but the chief result is the same, whatever the cause, *viz* an inflammatory

infiltration of the muscle with increasing discomfort on attempting movement The part feels hard and rigid and may be tender to the touch

If suppuration ensues the ordinary signs of an abscess appear A certain amount of contractile tissue is thereby destroyed and cicatricial changes may lead to deformity Contraction of tendons with resulting deformity may therefore be produced by any condition which leads to destruction of muscle substance Occasionally it develops in the absence of open wounds as in Volkmann s contracture and certain nerve lesions A number of varieties of myositis have been described

Simple Traumatic Myositis. This results from contusion or laceration of the fibres and is a plastic inflammation with or without hæmorrhage which may completely resolve or leave a little fibrosis As a result some contractile tissue may be replaced by fibrous tissue

Volkmann s Ischæmic Contracture A comparatively rare condition it is seen usually in children as a complication of fractures of the lower end of the humerus or of the bones of the forearm It is also occasionally seen after fractures of the femur or upper end of the tibia and then affects the calf muscles.



FIG. 10 6. VOLKMANN S CONTRACTURE OF THE FOREARM MUSCLES FOLLOWING A FRACTURE AT THE ELBOW

The operation scar and the scar of the pressure sore in the mid forearm can be seen.

The essential lesion is an ischæmia of the flexor group of muscles caused by spasm or blockage of the lumen of the main artery brachial, popliteal or posterior tibial. Bruising or laceration of the arterial wall by the bone fragment takes place, either at the time of the original injury or subsequently by attempts at reduction of the fracture.

The blood supply to the limb is further reduced by spasm of the collateral circulation Although gangrene may result, there is usually a sufficient blood supply to prevent this occurence. Ischæmia of the muscle causes degeneration of the muscle fibres and this is followed by fibrosis which in turn leads to contracture. The resulting *claw hand* differs from that seen after an ulnar nerve lesion in that all the digits are affected When the wrist joint is fully flexed the fingers can be straightened to some extent

but when the wrist is extended the fingers are clenched tightly into the palm

Controversy has raged for many years as to the part played by tight plaster of Paris splints and by bandages, in the production of ischæmia. It is now accepted that arterial damage is the main factor and that the plaster or bandages play only a secondary part, when the limb begins to swell. Ischæmia can occur in a limb which has never been encased in plaster

Delay in reduction of a supracondylar fracture of the humerus or repeated attempts at reduction in late cases in which there is already excessive swelling, may cause arterial damage. Hyperextension of the elbow as an aid to reduction, is dangerous and should be avoided

Diagnosis It is important to appreciate the signs which herald the onset of ischæmia These will be considered in relation to supracondylar fracture of the humerus.

Pain may be excessive and will be aggravated by attempts at passive extension of the fingers, which in the early stages are flexed by muscle spasm. The fingers may be cold, white, or swollen and cyanotic. The capillary circulation in the nail-bed is sluggish and the radial pulse absent, though this does not necessarily mean that a contracture will follow The fingers are numb Loss of motor power in the flexor muscles is a danger signal

Prevention. The main factors in preventing the onset of this crippling condition are (*a*) early reduction of the fracture, avoiding excessive force or hyperextension and never applying a skin-tight plaster in a case of recent injury (*b*) the immediate splitting of the plaster and underlying bandages, right down to the skin should ischæmia be suspected

Treatment If in spite of preventive measures, ischæmia persists, exploration of the brachial artery in the antecubital fossa, is advisable. Removal of blood clot and gentle swabbing of the artery with procaine or papaverine may help If there is visible damage to the artery excision of the damaged segment is indicated. Because of gross swelling, which is always present, closure of the wound may be difficult and sepsis may introduce a further hazard.

When actual contracture is established treatment may be very difficult. Slow stretching of the flexor muscles by splinting, should be tried but if this fails, some improvement may be obtained by tendon lengthening or bone shortening.

Rheumatic Myositis (*Muscular Rheumatism*) These are clinical terms used to describe pain arising in the muscles or fascia. The expression *fibrositis* is used in a similar fashion. The pains are at times vague and at others severe, difficult to locate with accuracy and often disappearing spontaneously

It is obvious from this description that these symptoms are common to many causes and that muscular rheumatism or fibrositis cannot be attributed to any single pathological lesion. An example is *lumbago* or pain in the lumbar region, of which the known causes may be tuberculous caries of the lumbar vertebræ, malignant metastases or lesion of the intervertebral discs

Treatment The cause of the pain should be treated but if this cannot be found, symptomatic treatment is instituted consisting of bed rest, heat and analgesics Immobilization in a plaster jacket or corset may enable the patient to get about, before all the symptoms have subsided.

Acute Suppurative Myositis. This condition is due to infection with pyogenic organisms. Damaged or dead muscle is an excellent medium for

the growth of anærobic organisms Penetrating wounds spread from bone or infection of a hæmatoma by blood borne organisms may be responsible Gas gangrene and tetanus two of the major causes of suppurative myositis are described in Chapter 1

Treatment Efficient drainage must be provided by wide incision of the deep fascia When dealing with penetrating wounds all dead muscle tissue must be excised Splinting to prevent contractures is important

Tuberculous Myositis. Invasion of a muscle sheath by tuberculous granulation tissue and caseous material from a neighbouring joint or bone may lead to secondary myositis A psoas abscess may arise in connection with tuberculous disease of the lumbar spine a condition which is considered in detail in Chapter 17

Syphilitic Myositis. Gumma of muscle is a manifestation of tertiary syphilis. Any muscle may be involved but the tongue and the sternomastoid muscle are said to be most often affected Care is needed in order to diagnose these conditions from tumours but the presence of a syphilitic history and a positive Wassermann reaction, the slow growth the hardness with subsequent central softening and the rapid disappearance after the administration of penicillin should suffice to determine their nature.

Occasionally gummata appear in muscles in the shape of small hard and shotty nodules usually arranged more or less longitudinally which are painless and apparently attached to the fascial sheath

Parasitic Myositis. Two parasites are found in skeletal muscle.

Trichina spiralis This is a nematode worm found in the flesh of the pig and other animals raw or partially cooked pork being the source of infection in man. The female worm lays her eggs in the villi of the intestine from which



FIG. 10 7 PARASITIC MYOSITIS CYSTICERCOSIS CELLULOSÆ.

the embryo worms pass into the blood stream and thence to skeletal muscle. Each embryo penetrates a muscle fibre, which swells and degenerates. Eventually the embryo worm becomes encapsulated and it is these calcified capsules which can be seen as minute white specks in exposed muscle tissue.

The disease may be serious, with fever diarrhœa, œdema, profuse sweats and the patient may die. The skeletal muscles become swollen stiff and painful, but gradually as the worms become encapsulated, the symptoms disappear

Tænia solium This is a tapeworm or cestode whose eggs are found in the intestine of the pig. The larvæ of the worm pass to the muscles in which they become encysted (cysticercus cellulosæ) Occasionally the eggs gain access to the human intestine and man then becomes the intermediate host, with the development of cysticercus cellulosæ in his muscles and other organs (Fig. 10 7) The cysts of another form of tapeworm *T saginata*, may be found in beef

Myositis Ossificans Progressiva. This rare disease is seen mostly in young males. Various muscles, especially those of the back, are transformed



FIG. 10 8 MYOSITIS OSSIFICANS PROGRESSIVA IN THE BICEPS BRACHII. (The skiagram is a "positive.")

into bony plates or rods, so as to lead to extensive ankylosis. The process seems to be one of ossification of the connective tissue associated with atrophy of the muscular fibres, and is sometimes extremely painful In a boy under observation, the arms were immobilized by ossification of the latissimus dorsi muscles on either side, while the pectoralis major and flexor muscles of the right arm were also ossified (Fig. 10 8). The erector spinæ was involved, the back being rigid, and the right trapezius was undergoing the same change This disease is often associated with a congenital deficiency of the proximal phalanx of the great toes. No treatment has proved of any value.

Traumatic Myositis Ossificans. This is quite distinct in nature from myositis ossificans progressiva. Two varieties are described

(1) The new formation results from persistent and repeated irritation of muscles or tendons and usually starts from the periosteal attachment. The "rider's bone" developed in the tendon of the adductor longus is of this description

(2) Commonly the affection follows a severe injury to a muscle associated with a fracture or dislocation whereby the periosteum is torn and bone cells (osteoblasts) are set free. A certain amount of hæmorrhage follows and in the reparative tissue developed in the muscle the bone cells find a suitable nidus for development and the new tissue formed undergoes ossification. In about three or four weeks the presence of bone can be recognized by



FIG. 10 9 MYOSITIS OSSIFICANS.
On the left, following dislocation of the elbow joint on the right, following an injury to the thigh.

palpation as a deep indurated mass, usually movable on the bone and across the fibres of the muscle involved at a later date the new bone can be seen by radiography (Fig. 10 9) Severe pain and limitation of movement may result. The muscles commonly affected are the brachialis muscle after supracondylar fracture of the humerus or dislocation of the elbow and the quadriceps femoris after trauma to the thigh. Treatment consists of rest until skiagrams show that the new bone is sharply demarcated. Active movements are then allowed passive movement or stretching being avoided at all costs. Occasionally removal of the bony mass may be necessary as a late procedure.

Tumours in Muscles. These are not very common and the majority start in the fibrous sheaths of the interfibrillar connective tissue. Primary growths consist of angioma, lipoma fibroma, chondroma myxoma and sarcoma. Tumours of the muscle fibres are very rare but malignant rhabdomyosarcoma

does occur Of the connective tissue tumours the commonest benign neoplasm is the lipoma and the commonest malignant neoplasm the fibrosarcoma. A parosteal variety which arises in the attachment of the muscle to a bone is usually considered with tumours of bone Secondary deposits of both carcinoma and sarcoma also occur

Treatment This follows ordinary surgical principles. If sarcomatous, the whole thickness of the muscles should be excised as far as their attachments, where possible, since the lymphatics run in the direction of the fibres but the sheath forms a limit not early overstepped. Amputation of the limb is often required. As a rule these growths are not very radiosensitive

Diseases of Tendon Sheaths

Acute Simple Tenosynovitis. This may result from excessive use of the part and is often seen in factory workers who perform repetitive movement many hundreds of times a day The use of a hammer may bring about the condition in one unaccustomed to it. The short extensor muscles of the thumb are commonly affected and the condition is also seen in the tibialis anticus muscle and its tendon, after excessive walking exercise

On examination there is a swelling over the course of the muscle or tendon and a characteristic fine crepitus can be felt when the muscle is contracted. It is apparent that both tendon sheath and muscle sheath are involved.

Treatment consists of rest in plaster combined with heat. When the acute symptoms have subsided cautious active movements may be started.

Acute Suppurative Tenosynovitis. This may result from a puncture wound of the synovial sheath, or the inflammation may spread to it from neighbouring tissues. Suppuration may extend both up and down the sheath, unless it is promptly treated by incision and antibiotics the tendon will slough, or may contract extensive adhesions to neighbouring parts. In either case considerable impairment of function is likely to follow When the tendon survives, active movements must be started very early if the formation of serious adhesions is to be prevented. The suppuration may affect neighbouring articulations, leading to their disorganization especially in the case of the tendon sheaths around the wrist joint Acute tenosynovitis of the hand is described on p 18

Chronic Simple Tenosynovitis. This is a common affection characterized by an effusion into the tendon sheath of glairy synovial fluid, somewhat resembling uncooked white of egg. An elastic fluctuating swelling forms in the course of the tendon usually associated with creaking. There is no pain or tenderness, but the affected part feels weak Treatment consists in counter irritation and pressure failing this, the swelling may be excised.

Stenosing Tenovaginitis. The condition is usually traumatic in origin and is the result of a sprain or repeated sprains of a finger or thumb It occurs chiefly in manual workers, particularly women. The lesion is a local fibrous thickening of the tendon sheath which causes constriction of the enclosed tendon. Often an œdematous swelling is found on the tendon above or below the constriction.

de Quervain's Disease The condition is found commonly affecting the short extensors of the thumb A tender nodule is present in the region of the radial styloid and pain on abduction of the thumb is the usual symptom (Fig. 10 10)



FIG. 10 10 STENOSING TENOVAGINITIS (DE QUERVAIN'S DISEASE).
A nodule is seen over the radial styloid process.

Snap Thumb This is a condition allied to trigger finger in which there is an obstruction to the free movement of the long flexor tendon of the thumb, caused by a thickening of the sheath as it passes between the two sesamoid bones at the metacarpophalangeal joint. A variety is sometimes seen in infants and may be bilateral The terminal joints are flexed and cannot be extended

Trigger Finger The middle and ring fingers are usually affected When the patient attempts to straighten the finger from the flexed position, she finds that this can only be managed with an effort and the finger finally snaps straight.

The most effective treatment for these conditions is to relieve the con striction by a longitudinal incision in the tendon sheath concerned Operation is the only treatment which is of any avail and is nearly always successful. The operation can be performed under local analgesia an incision is made through the skin over the swelling and the superficial fibrous sheath of the tendon excised

Chronic Tuberculous Tenosynovitis. This is of two types. In one the sheath is lined by œdematous granulation tissue of some thickness, containing tuberculous foci, giving rise to a soft elastic swelling along the course of a tendon which increases slowly in size. It is only slightly painful or tender Suppuration may follow and subjacent bones or joints be involved

The other form of tuberculous disease consists in an effusion into the synovial space, the lining membrane of which becomes thickened by the deposit thereon of fibrinous material This is often detached and by the movements of the part the loose fragments of fibrin are moulded into various shapes. In tendon sheaths they are often elongated constituting the so-called melon-seed bodies when they occur in joints, they remain somewhat flattened while in bursæ they approximate more to the spherical. On examination, they are found to be structureless, though sometimes laminated

When numerous, they give rise to a curious and characteristic form of crepitus That they are of a tuberculous nature can be demonstrated by inoculation experiments, but the bacilli in them are not in a very active state, and the prognosis of this type is more favourable than that of the former

Compound Palmar Ganglion This term is applied to tuberculous disease of the common synovial membrane surrounding the flexor tendons of the wrist, the cavity being distended in the early stage with a glairy fluid usually containing many melon-seed bodies, and perhaps later on with pus In the early stages all that is noted is a fulness about the front of the wrist and palm the normal hollow being obliterated. Later on a more definite swelling is observed, and this is found to extend into the thenar eminence, due to the involvement of the tendon sheath of the flexor longus pollicis The condition is painless at first, and there is but little interference with the mobility of the tendons but in the later stages the tendons may become matted together



Fig 10 11 Tuberculous Compound Palmar Ganglion

The swelling can be seen bulging above and below the annular ligament of the wrist.



Fig 10 12 Ganglion on the Dorsal Aspect of the Foot

and the movements of the fingers hampered or if the disease ends in suppuration the pain and disability become more marked In all stages fluctuation can usually be detected above and below the annular ligament, being transmitted beneath it (Fig. 10 11)

Treatment This consists first in the general treatment of the disease and secondly in immobilization of the affected part. A careful search for active tuberculosis in the lungs, genito-urinary tract and elsewhere is made If no such active focus be found the question of radical excision of the whole mass of tuberculous granulation tissue must be considered. The operation consists of a tedious dissection of the diseased tissue from the tendons, suture of the wound, and a period of immobilization in plaster

Ganglion. This term is given to a localized cystic swelling forming in connection with a tendon sheath or joint. It is most commonly met with at the back of the wrist, but it sometimes occurs on the front of the wrist or

in the foot (Fig 10 12) It varies considerably in size and contains a clear transparent gelatinous or colloid substance A rounded firm elastic swelling is produced usually somewhat movable At first it is neither tender nor painful although pain may be experienced as it increases in size Trauma is the probable cause of the ganglion It is thought to arise as a mucoid degeneration in fibrous tissue of a tendon sheath or joint In support of this is the histological finding of a fibrous capsule containing a jelly like substance without any evidence of synovial lining Little difficulty arises in diagnosis, although when situated deeply and closely attached to a bone they may be mistaken for exostoses

Treatment A ganglion may often be ruptured by manipulation and pressure with the thumbs Failing this a rapid cure is usually obtained by an aseptic puncture of the cavity with subsequent application of firm pressure In some cases it may be advisable to dissect out the whole cyst as completely as possible The operation should be performed under a general anæsthetic, using a tourniquet to ensure a bloodless field and strict aseptic precautions

Tumours of Tendon Sheaths. Both innocent and malignant synovioma may occur in connection with tendon sheaths. A soft rounded swelling is seen on the dorsal or lateral surface of the finger (Fig. 10 13) Excision of



FIG 10 13. SYNOVIOMA OF THE EXTENSOR TENDON OF THE LITTLE FINGER.

small tumours is quite easy but recurrence may take place because malignancy is unsuspected. On section the tumour mass may be of an orange yellow consistence and giant cells are in evidence but are histologically distinct from those found in so-called giant-celled tumours of bone The yellow colour arises from xanthomatous material which is found in benign synovial tumours. Malignant synovioma metastasizes readily and amputation of the digit or limb together with block dissection of the regional nodes may be required.

Operations on Tendons

Tenotomy

This means the division of a tendon through an open or subcutaneous wound with the object either of remedying some deformity such as talipes or torticollis, or of assisting in the reduction of some displacement, as in setting a fracture. The subcutaneous method is employed where there is little likelihood of injuring important structures. The strictest attention to asepsis is essential, since the character of the wound, *viz.* a puncture, and the entire absence of drainage, are most favourable to the growth of

organisms if entrance is once given to them. The open method is to be preferred in that neighbouring structures are guarded from damage, and the tendon may be accurately divided and sutured at the desired length. The only objection is that a scar is left which may be unsightly

When the operation is completed the deformity is corrected and the part immobilized for a variable period but one which may be as much as six weeks in the case of a powerful tendon such as the tendo Achillis. Tenotomy is performed chiefly on the following tendons

The Tendo Achillis The foot is placed on its outer side, and the tendon relaxed by pointing the toes downwards. The tenotome is introduced at the inner margin of the tendon, about one inch above its insertion either superficial to or beneath it. The tendon is readily divided when the foot is dorsiflexed if the surgeon cuts towards the skin he must not divide the last few fibres too rapidly otherwise a considerable external wound may be inflicted by the suddenly liberated knife

The Tibialis Anterior This should be divided about one inch (2 5 cm.) above its insertion as it crosses the navicular and is free from a synovial sheath It is first relaxed so as to allow the introduction from the outer side of the sharp pointed tenotome beneath it this is replaced by a blunt ended instrument, and the section is accomplished when the foot is abducted.

The Tibialis Posterior This is divided, together with the flexor digitorum longus, just above the medial malleolus about a finger's breadth from the tip of that process in an infant, and about 1¼ inches (3 cm.) from it in an adult. The knife is inserted between the tibia and the tendon, and if correctly placed, remains fixed without support of the hand, being grasped between the tendon and the bone. The blunt-ended tenotome is then introduced with its edge towards the tendon, the latter structure being divided when the foot is dorsiflexed.

The Peroneal Tendons These should be divided just above the base of the lateral malleolus, at a spot where the synovial sheath is usually absent. The tenotome is inserted close to the fibula between the tendons and the bone.

The Biceps Cruris This tendon is best divided by an open operation so as to avoid the lateral popliteal nerve which has often been wounded in the subcutaneous method. An incision is made in the direction of the tendon, just above its insertion into the fibula It is then lifted upon an aneurysm needle and divided muscular fibres will probably be found quite close to its lower end.

Semimembranosus and Semitendinosus Tendons These are divided just above the knee-joint, and the subcutaneous operation may be conveniently adopted when they are prominent and tense.

The Sternomastoid Tendon This tendon may require division in children with torticollis, a condition which is described in Chapter 11

Lengthening a Tendon. This is necessary in order to overcome the deformity which results from loss of substance or contraction, where simple tenotomy does not seem desirable. The most efficient method is the so-called Z-operation (Fig. 10 14A) The tendon is split longitudinally into two halves which are separated one from the other by cross-cuts made on opposite sides, one at each end The two flaps are then drawn apart for a distance corresponding to the increase in length required, and sutured together the resulting bond of union will be as represented in Fig. 10 14B This

operation is usually performed through an open wound, but for the tendo Achillis it is quite easy to undertake it as a subcutaneous procedure. The tendon is half-divided on opposite sides through two punctures 1½ in (3 5 cm) apart and then by forcible dorsiflexion the two halves of the tendon are made to slide on one another until the required lengthening is obtained

Shortening a Tendon. This is needed in some forms of paralytic talipes The Z method may also be employed here the two halves after they have been separated being shortened to the required amount and then stitched together (Fig 10 14C) This operation gives a more solid bond of union than when a transverse or an oblique section is removed in such the sutures are more likely to cut out

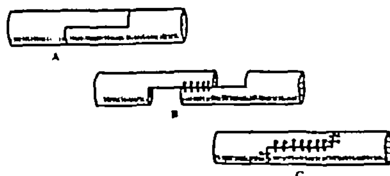


FIG. 10 14 Z-OPERATION FOR LENGTHENING OR SHORTENING A TENDON.
In A the method of dividing the tendon is shown. In B the flaps are slipped downwards, one on the other so as to lengthen the tendon. In C equal portions have been cut away from each half and the ends sutured, so as to shorten it.

Tenoplasty This term is applied to any plastic operation on tendons with a view to (*a*) transfer the action of a healthy and strong muscle to the tendons of a weakened or paralysed group, so as to limit deformity or disability (*b*) displace the line of action of a muscle so as to counteract or obviate deformity (*c*) utilize a paralysed tendon as an accessory ligament Clearly this operation finds its greatest use in paralytic affections. It is essential to study carefully the peculiar features of each case, especially the electrical reaction and power all of the muscles involved and the relative importance of each possible movement Thus, in the foot, plantar flexion is of more value than dorsiflexion and the latter is more useful than either adduction or abduction while of the two last mentioned movements adduction is more important than abduction. Hence, although it would be mechanically correct to transplant a healthy abductor such as the peroneus longus, into a paralysed plantar flexor such as the tendo Achillis, so as to improve plantar flexion at the expense of abduction it would be unwise to reverse the procedure. *It is desirable that, whenever possible* the reinforcing tendon should be derived from a synergic and not from an opposing group

Various methods of tenoplasty are available (*a*) *Tendon implantation* consists in suturing the whole or part of the proximal end of the tendon of a healthy muscle to the distal end of the divided tendon of a paralysed muscle, and for choice the latter should be divided as near its insertion as possible. The actual method of union of the tendons varies with circum-

stances, but the best results have been obtained by tunnelling the healthy tendon and drawing the divided end of the paralysed tendon through it, and uniting them thus by sutures (Fig. 10 15). Direct end-to-end suture of two tendons is less satisfactory Occasionally merely a slip from the stronger tendon is employed, which is attached to the weaker one so as to fortify the latter without destroying the power of either (*b*) By *tendon transplantation* is meant the total detachment of a tendon from its point of insertion, with or without the periosteum or bone to which it is attached and its transference and fixation to the point of insertion of the tendon of a paralysed muscle, or to some spot where it can act more advantageously It is fixed either by sutures to the periosteum, or by drilling a hole through the bone and threading the tendon through it. (*c*) A somewhat similar procedure which may be

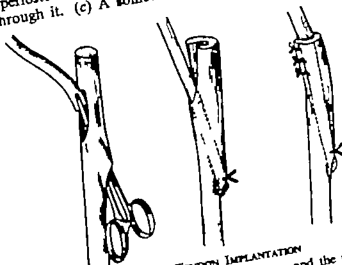


Fig. 10 15 Tendon Implantation

A hole is tunnelled obliquely through the healthy tendon, and the paralysed tendon is drawn through this and fixed by sutures. At the free end the receiving tendon is split longitudinally and wrapped round the paralysed tendon, so as to improve the fixation.

termed *tendon fixation*, is sometimes employed in order to steady flail-like paralysed parts. Thus in hopeless foot-drop of paralytic origin it may be desirable to divide the extensor or peronei tendons and attach their distal segments by suitable methods to the tibia to act as accessory ligaments.

The greatest care must be taken with the technique of these operations, so as to ensure complete asepsis and perfect hæmostasis. Tendon sheaths must be closed by the finest catgut or silk sutures. Deformities should be corrected before the tendons are united, so as to ensure accurate length of the new structure. The after treatment is in the first place directed to the avoidance of undue tension on the bond of union for fear that it may stretch. The parts should be kept in an over-corrected position for six weeks by splints or plaster of Paris. Subsequently a supporting instrument may be worn for six months and the affected muscles treated by massage, electricity and educative exercises.

Diseases of Bursæ

Bursæ exist as normal structures in many parts of the body exposed to pressure, their object being to diminish friction and permit of a gliding movement. Similar cavities, known as abnormal or *adventitious bursæ*

are developed in regions where exceptional pressure is brought to bear on some prominent structure they consist of a fibrous wall lined by a serous membrane contain a small quantity of serum and are formed either by dilatation of lymphatic spaces or as a result of a localized effusion into the tissues Examples of this are met with in men following special occupations e g over the vertebra prominens of Covent Garden porters and then known as a "hummy" Billingsgate fish-carriers occasionally have bursæ under the centre of the scalp deal runners often present one on the upper part of the shoulder They occur over bony prominences arising from malformation or displacement e g over the cuboid in talipes equinovarus and over exostoses the false joint or pseudoarthrosis which occurs in unreduced dislocations or ununited fractures is of a similar nature

Wounds of Bursæ These may be caused by penetrating injuries or sometimes by the skin over them splitting, as e g in a fall on the point of the olecranon The escape of bursal fluid which results often prevents healing, and then it will be necessary either to excise the bursa or to open it freely so that it can be packed and allowed to heal from the bottom

Subcutaneous injuries are followed by hæmorrhage and the hæmatoma may suppurate or become absorbed in the latter case adhesions will often occur and even polypoid fringes from the organization of the blood-clot Treatment consists in keeping the part at rest, unless suppuration is threatening, when an incision must be made It is always well to make certain that no fracture is present beneath a hæmatoma of the olecranon or patellar bursæ

The following conditions may affect adventitious as well as normal bursæ

Acute Simple Bursitis. This is caused by injury or prolonged irritation especially in gouty or rheumatic individuals. The part becomes swollen painful and tender and, if superficial, the skin over it may be hyperæmic Effusion into the cavity quickly occurs, and is sometimes mixed with blood Lymph is deposited on the serous surface and in many cases results in the formation of adhesions possibly obliterating the cavity Treatment consists in keeping the part at rest and applying fomentations. If the effusion persists, aspiration or removal by trocar and cannula under strict asepsis, may be employed or the whole cavity excised

Acute Suppurative Bursitis. This may follow infection occurring either from without or within it not uncommonly follows a subcutaneous injury of a chronically inflamed bursa leading to its distension with blood. The pus, formed at first within the bursa may travel directly to the surface, or bursting through the capsule diffuse through the tissues Where this occurs, the characteristic feature suggesting a bursal origin of the abscess may be masked Thus, in suppuration of the bursa patellæ, the pus often finds its way to the lateral aspects of the limb allowing the patella to be distinctly felt through the skin the case might then be mistaken for suppuration within the knee joint, but is easily distinguished by the absence of the more acute arthritic symptoms. Involvement of subjacent bones and joints sometimes occurs, thus the patella or olecranon may become carious or necrose. Treatment resolves itself into an early free incision, and drainage

Chronic Bursitis with Effusion. This is the most common pathological condition met with in bursæ The cavity becomes distended with a serous effusion of varying amount giving rise to a fluctuating swelling. The walls differ in thickness according to circumstances if the condition is one of

long standing with frequent recurrences, the bursal wall is usually reticulated and dense and adhesions papilliform processes, or fibrous cords are often produced Subacute exacerbations are frequent. Treatment consists in rest aspiration and the application of a firm pressure bandage. If this fails, the bursa should be dissected out When the bursa communicates with a joint such as that under the semimembranosus tendon the neck must be isolated, and its communication with the joint shut off by ligature.

Chronic Tuberculous Bursitis. This is characterized by effusion and the presence of loose fibrinous bodies (melon-seeds) or the lining membrane is transformed into granulation tissue of a tuberculous type perhaps leading to the formation of a chronic abscess. Either condition may be secondary to a tuberculous arthritis or may give rise to it, when the bursa communicates with a joint. If total removal is impracticable, treatment is similar to that for chronic tuberculous tenosynovitis.

Syphilitic Bursitis. This is described in bursæ as either a symmetrical bursitis with effusion in the early stages, or later as a gummatous perisynovial development. In this variety often termed *chronic fibroid bursitis* the walls of the bursa are much thickened, constituting a hard fibroid tumour in the centre of which is a small cavity If the gummatous material breaks down deep openings may develop into the swelling. Antisyphilitic treatment should be instituted.

Gouty Deposits. These may occur in the walls of bursæ and constitute tophi The irritation may predispose to abscess formation pus mixed with urate of soda crystals being discharged. The olecranon bursa is the one most frequently affected in this way

Special Bursæ. *The Bursa Patellæ* Since this lies over the lower half of the bone and not over its centre, it is very liable from its exposed situation



FIG. 10 16. ENLARGED BURSA PATELLÆ.

to injury or any of the above-mentioned varieties of bursitis. In its simplest form it constitutes the condition known as " housemaid's knee " and is due to kneeling. Caries of the patella may follow acute suppuration and the more chronic varieties may lead to osteoplastic periostitis. The knee-joint itself usually escapes infection

The Bursa beneath the Ligamentum Patellæ When distended with fluid this gives rise to a fluctuating swelling felt on either side of the tendon more

especially when the limb is extended when the leg is flexed the swelling diminishes Chronic enlargement of this bursa may push the synovial alar folds back into the joint so that they are nipped between the bones whenever the patient attempts to stand with the leg extended the pain thereby induced is somewhat similar to that caused by a displaced semilunar cartilage or by a loose foreign body in the joint The presence of the enlarged bursa together with the inability to stand with a straight leg should suffice to make the diagnosis clear

The Bursa in the Popliteal Space Enlargement of the bursa between the inner head of the gastrocnemius and the semimembranosus (Fig 10 17) leads to a rounded fluctuating swelling sharply limited on its outer aspect and more fixed and less defined towards the inner The sensation imparted



FIG. 10 17 SEMIMEMBRANOSUS BURSA.

to the fingers varies according to the position of the limb the swelling being tense in extension and flaccid in flexion as occurs in most of these periarticular bursæ. Owing to the proximity of the popliteal vessels pulsation is occasionally detected but is not expansile in character Enlargement of this bursa is often secondary to an articular lesion especially tuberculous disease or osteo-arthritis, and before undertaking treatment the condition of the joint should be ascertained If the joint is healthy the bursa may be removed by dissection, the pedicle being closed by ligature or suture.

In children a similar type of swelling is more often a ganglion and transillumination should be done. It is often necessary to excise this but aspiration is sometimes sufficient

The Bursa beneath the Insertion of the Semitendinosus and Gracilis This may be inflamed, and is very liable to cause osteoplastic periostitis of the subjacent inner surface of the tibia.

The Bursa beneath the Tendo Achillis If enlarged this presents a fluctua

ting swelling on either side of that structure somewhat simulating disease of the ankle joint, but necessarily limited to the posterior aspect of the joint. Primary tuberculous disease is sometimes present.

A superficial adventitious bursa is often present over the insertion of the tendo Achillis The bursa is commonly seen in young women and is the result of pressure of the heel of an ill fitting shoe. Treatment should in the first instance be conservative, open-backed shoes or sandals should be worn. Persistent symptoms may require removal of the bursa and it is wise also to shave off the underlying prominence of the calcaneum.

The Bursa beneath the Psoas Tendon. Distension of this gives rise to a fluid swelling which usually projects anteriorly presenting either on the outer or inner side of Scarpa's triangle If painful, it necessitates flexion of the thigh, and thus leads to symptoms resembling those of hip-joint disease or of a psoas abscess. It must not be forgotten that this bursa often communicates with the hip joint.

The Gluteal Bursa. This is situated between the insertion of the gluteus maximus and the great trochanter is not uncommonly the seat of tuberculous disease. It presents as a rounded swelling, obliterating the hollow behind the trochanter and in its more acute manifestations may be accompanied by abduction and eversion of the limb in order to relax as far as possible the gluteus. It may thereby somewhat resemble the earlier stages of hip disease, but is recognized by the absence of flexion and by the fact that passive movements, including even the so-called test movement for hip disease, can be undertaken with but little or no pain Should suppuration occur the pus may burrow widely beneath the gluteus maximus Treatment consists of complete excision if possible or incision with scraping and disinfecting the interior allowing it to heal from the bottom Necessarily part of the insertion of the gluteus maximus will require division and must subsequently be sutured.

The Bursa over the Tuber Ischii If inflamed this gives rise to the condition known as "weaver's bottom" it causes great discomfort in sitting and is often solid and symmetrical. If troublesome, it should be removed.

The Bursa over the Olecranon This constitutes the condition known as "miner's elbow or "beat-elbow" suppuration within it is common, leading to necrosis of the underlying bone the elbow joint is rarely affected.

The Subdeltoid Bursa This extensive bursa may be enlarged and become the site of a simple chronic effusion or of a tuberculous hydrops with melon-seed bodies. It leads to prominence of the deltoid and expansion of the shoulder which is liable to be mistaken for an effusion into the shoulder joint. This should be recognized without much difficulty as the swelling is usually greater and there is no axillary extension Treatment consists of rest, aspiration, or removal of as much as possible of the bursa by dissection.

Rotator Cuff Lesions of the Shoulder

The rotator cuff of the shoulder consists of the capsule of the joint into which the rotator muscles are inserted Three pathological conditions will be considered

Periarthritis of the Shoulder This condition which is also called pericapsulitis subdeltoid bursitis or "frozen" shoulder is the commonest cause of shoulder pain and stiffness. True arthritis of the shoulder whether due to osteo-arthritis infection or tuberculosis, is comparatively rare. The in-

flammatory changes in periarthritis are mainly confined to the capsule and associated tendons the rotator cuff This structure is the site of a cycle of changes hyperæmia organization of œdema fluid and the deposition of fibrous tissue Considerable thickening and loss of elasticity is the result with consequent pain and limitation of movements The subdeltoid bursa may be affected but is not the main site of the pathological changes

The condition is confined to middle age and there are several clinical types (*a*) following trauma to the tendons of the rotator cuff (*b*) following excessive use of the arm for unaccustomed work such as sawing wood (*c*) a gradual onset with no apparent cause especially common at the menopause and (*d*) following chest operations such as pneumonectomy or thoracoplasty In such as the last the question of a tuberculous joint must be considered Search for a septic focus is usually fruitless but when both shoulders are involved it is tempting to think that such may exist.

In the early stages pain and muscle spasm are the main features. Later the pain grows less and limitation of movement becomes more marked until in severe cases the joint may be practically ankylosed Gradually the con-



FIG 10 18 CALCIFIED DEPOSIT IN THE SUPRASPINATUS TENDON.
(The skiagram is a "positive.")

dition tends to improve the whole cycle taking from six to twelve months Some permanent limitation of movement may remain although most patients regain an active and useful range in the shoulder joint. Recurrent attacks may occur

In the stage of spasm rest of the arm in a sling combined with analgesics is essential. Physiotherapy is of doubtful value but heat or diathermy may be tried. Active movements within the limit of pain are permitted Later more activity is encouraged. Should the range of movement not improve manipulation under an anæsthetic may be required.

Rupture of the Supraspinatus Tendon. This may be partial or complete and may occur when a sudden strain is put upon the abducted arm. Severe pain is felt and the arm falls to the side. Subsequently the patient is unable to initiate the act of abduction but if assisted for the first few degrees the

deltoid muscle can then continue the movement. When a complete rupture is suspected the capsule should be explored and the tear repaired. Partial ruptures are difficult to diagnose with certainty The arm should be rested in a sling until pain has gone and the movement restored by active exercise It is probable that many cases of supraspinatus tendinitis start at the site of a partial rupture of the tendon.

Supraspinatus Tendinitis. The inflammation is localized to the region of this tendon. Degeneration followed by calcification may occur (Fig. 10 18) The typical finding is that of pain on abduction of the arm which is felt between 70° to 120° of abduction—the painful arc. The pain coincides with the contact of the inflamed tendon against the under surface of the acromion and ceases when the tendon has slipped completely beneath it. Other movements are full.

Treatment is on the lines of that for periarthritis. A calcified deposit may require aspiration or open operation to remove the encysted material

Chapter 11

DEFORMITIES

Introduction

Orthopædic Surgery is concerned with the abnormalities diseases and injuries of the locomotor system This system includes those structures which constitute the limbs—skin fascia muscle blood vessels and nerves bones and joints. The spinal column pelvic girdle and walls of the chest and abdomen are also included The normal functioning of these parts cannot take place unless the body as a whole is normal and therefore abnormalities of the locomotor system must be considered in relation to the systems of the body For example muscles cannot undergo voluntary contraction unless the nerve supply connecting them to the spinal cord and brain is intact and unless an adequate blood supply is present. The act of walking cannot be accomplished unless there is correlation between the special senses of balance position and the locomotor system It follows therefore that the study of a particular abnormality must embrace not only the examination of that part but must also include a survey of the patient as a whole, with special attention to the nervous and vascular systems. The study of *function* may be of greater importance than the more obvious static deformity which first catches the eye.

Deformities may be postural or structural.

Postural Deformity This may be corrected by a voluntary effort on the part of the patient or made to disappear under an anæsthetic There is no alteration of the anatomical structure of the part e g postural round shoulders of adolescents. Hysterical deformities come into this category

Structural Deformity By contrast this is a fixed deformity because of changes in the anatomy of the part. It cannot be corrected by a voluntary effort nor under an anæsthetic unless force be used or division of structures be undertaken.

In the study of a deformity it is well to consider the anatomy of the part. The primary abnormality may be in the bone or in the soft tissues. Soft tissue contraction may impose a continuous stress upon growing bone. Adaptation of bone structure to these stresses may lead to gross abnormalities of external form and of internal architecture, e g congenital club foot is at first a contracture of soft tissues skin, fascia, tendons and joint capsules. In the baby correction may be obtained by stretching these structures. If untreated until late childhood, the tarsal bones will have assumed an abnormal form and correction can be achieved only by reshaping these bones at operation.

Deformities occurring in childhood may progress rapidly during the growth period but increase little after growth has ceased.

Deformities or malformations can be considered under two main headings *congenital* and *acquired*

Congenital Deformities. These are present at birth. In some cases they are obvious at a glance, for example congenital club foot. In others, the deformity may not be noticed until some time later although the underlying abnormality was in fact present, *e g* a congenital dislocation of the hip may not be diagnosed until the child walks.

Our knowledge of the causes of congenital deformities is far from complete, but it is useful to consider them under the following headings

Genetic. The deformity is inherited and may have been present in parents or grandparents, *e g* web fingers (syndactyly) dwarfs, and sometimes fragile bones (fragilitas ossium)

Errors of Development During the period of gestation, maternal ill health (*e g* virus infections, especially rubella during the first three months of pregnancy) may produce gross abnormalities in the infant. Cataract, deafness, mental deficiency and possibly deformities of the limbs or skeleton may occur Vitamin lack and dietary errors in the mother may also be responsible and there is much to learn in this field.

Mechanical Pressure in Utero This may be brought about by pressure of the uterine wall in circumstances where the amniotic fluid is deficient, or the child lying in an abnormal position It is thought to be a cause of some deformities and the theory is applied to explain the production of congenital club foot and congenital wry neck but there is no universal agreement on this point.

During Labour Abnormalities, the result of injury during labour are not strictly speaking, congenital, but are present at or soon after birth and may be considered here for convenience. During the birth of a child, mechanical injury may take place. *Birth fractures* to the limbs may occur from difficulty in delivery *Excessive moulding of the skull* may result in cerebral hæmorrhage or direct damage to the brain As a result, the child may die or if he lives, cerebral palsy with generalized spasticity or hemiplegia may result.

Anoxia. Partial deprivation of oxygen even for a short time may also cause permanent damage to the nerve cells. Mental deficiency spasticity and deformities may follow

Acquired Deformities. More than one factor may operate in the production of a deformity and sometimes different causes may lead to the same end result. In many instances the causative factors are quite unknown. Speculation may suggest that such things as muscle imbalance, irregular growth of soft parts or bone, and the influence of gravity may be responsible for the deformity We remain ignorant of the true cause of these deformities.

Acquired deformities may be considered under the following headings

(1) *Trauma.* Mechanical, physical or chemical injuries (burns, scalds) to the various anatomical structures may occur

Skin. Loss of skin with subsequent scar tissue formation may lead to contractures

Muscle. Destruction of muscle substance is repaired by fibrous tissue. The power of contraction may be lost and contracture may result, as in Volkmann s contracture which is described on page *173*

Vessels. Impairment of blood supply may lead to gangrene or ischæmia of muscles or nerves.

Nerves. Paralysis, anæsthesia and vasomotor changes result.

Joints Dislocations fibrosis or ossification in ligaments may lead to joint stiffness or ankylosis

Bones Fractures with malunion or non union are a common cause of deformity

(2) *Disease* A great number of diseases are responsible for the production of deformities

Neurological This may result in flaccid or spastic paralysis e g poliomyelitis disseminated sclerosis or muscular dystrophies

Bacterial Sepsis may lead to osteomyelitis or arthritis tuberculosis to lung fibrosis ankylosed joints or deformities of the spine and limbs

Metabolic Conditions such as osteomalacia and Paget s disease, in which the bones are decalcified and may bend

Arthritis The joint may be disorganized by destruction of the articular surfaces and of the ligaments This may occur both in acute and chronic joint disease Rheumatoid arthritis is a typical example of chronic joint disease resulting in deformity

Senility and Debilitation In these states where muscle tone is poor deformity may result from prolonged malposition with stretching of one muscle group and contraction of another e g drop-foot in the bed ridden patient for whom no bed cradle has been provided to relieve the foot from the pressure of the bed clothes.

Infantile Paralysis

This disease is the most common cause of paralysis in children. An acute inflammation in the anterior horn cells of the spinal cord (*acute anterior poliomyelitis*) results in destruction of the multipolar cells without suppura tion and is in some cases followed by paralysis and degeneration of the muscles supplied by these cells The disease is caused by a group of viruses which can be isolated from the stools of patients in the acute stage of the disease The inoculation of portions of an infected spinal cord into monkeys produces the disease and the cell-free fluid obtained after crushing up such cord débris and filtering through coarse porcelain, is similarly effective The virus remains active in a dried cord for some weeks.

Infection This is most commonly introduced *via* the gastro-intestinal tract, or in some cases by the nasopharynx. The virus has been recovered from the stools as long as eight weeks after the onset of the disease, but only lives for a few days in the nasopharynx. Infection is probably carried by the blood stream to the central nervous system, where it causes inflammation in the region of the anterior horn cells of the spinal cord and occasionally the brain.

Age incidence Children between the ages of two and eight years are at maximum risk, but there is an increasing tendency for the disease to attack children in the older age groups and adults.

Epidemiology The disease is one of temperate climates and is notifiable, in England. Sporadic cases occur each year with a rise in the late summer and autumn. There are occasional severe epidemics throughout the world such as that in Australia and more recently in the Americas and Mauritius.

During an epidemic, certain general precautions should be observed People should keep away from crowds in cinemas, theatres and other public places. In schools overcrowding in dormitories and classrooms must be

avoided as far as possible Swimming baths are a likely source of infection as is the eating of food or raw fruit which has been touched by hand There is evidence that the disease may follow operations for tonsils and adenoids, and the giving of combined diphtheria pertussis inoculations or other injections. These procedures should be temporarily discontinued. In those who become infected, severe paralysis may follow over-exertion, therefore strenuous games or exercises should be banned in schools during epidemics.

Vaccination by the Salk vaccine (an inactivated virus) gives immunity for about two years after which booster doses are required.

Finally a patient with poliomyelitis should be isolated for six weeks from the onset of the disease, with special precautions to prevent spread by fæcal contamination or droplet infection.

The clinical aspects of the disease may be conveniently considered in three stages (*a*) acute stage (*b*) stage of recovery (*c*) stage of permanent paralysis.

The Acute Stage. The disease may start in one of two ways, either as a febrile cold " or as a gastro-intestinal upset, with vomiting or diarrhœa. If the temperature is recorded on a chart, the characteristic " dromedary appearance may be seen *i.e* two humps with a normal period of a few days in between (This name is really a misnomer as a dromedary has one hump. It is the Bactrian camel which has two) The first hump may be accompanied by non-specific respiratory or joint symptoms and the second by headache and irritability followed immediately by paralysis. Head retraction is not seen and stiffness of the neck has to be looked for it may be demonstrated as an inability to " kiss the knees."

The cerebrospinal fluid findings are not constant. The pressure is rarely raised. There may be a rise in cell content from fifteen up to several hundred per cu mm. and these may be polymorphonuclear leucocytes lymphocytes, or both The protein content may or may not be increased early in the acute stage, but later it increases and the cell content diminishes. Because of these inconstant findings, lumbar puncture is not carried out as a routine diagnostic procedure

In some patients severe pain in the muscles is a marked feature and this pain may be mistaken for that of acute osteomyelitis acute rheumatic fever or even appendicitis

Paralysis is of the lower motor neurone or flaccid type. Many cases recover without paralysis, but in others it occurs within a few days of the onset. The paralysis comes on suddenly reaches its maximum within a few hours and may be widespread, including the limbs, spinal, abdominal and thoracic muscles The facial and sphincter muscles are rarely affected, but retention of urine may be a feature for a few days owing to inability to contract the muscles of the abdominal wall.

Respiratory paralysis may cause death from asphyxia unless immediate access to an artificial respirator is available (Fig. 11 1)

The lower limbs are affected more often than the upper but the distribution of paralyzed muscles is variable and corresponds to the patchy areas of degeneration to be found in cells of the cord in post-mortem specimens. In the arms the deltoid is commonly affected, in the legs the tibialis anterior and dorsiflexors rather than the calf muscles Wasting is rapid and there is a corresponding alteration in electrical excitability Reflexes are lost but sensation is normal

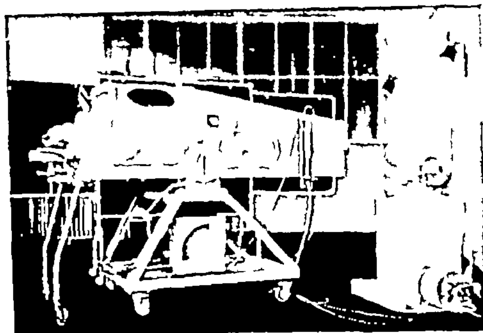


FIG. 11 1 DRINKER'S APPARATUS.

The acute stage indicated by fever pain and paralysis, may last up to six weeks.

The Stage of Recovery Some cells are killed others put temporarily out of action Of the latter some begin to regain their function quite rapidly others more slowly During the first three months, maximum recovery will take place so that at this interval it is possible to form a shrewd idea of the ultimate state of the patient However recovery of muscle may continue for as long as two years and certainly no operative treatment should be planned until a year has elapsed. After this, the slight gain in muscle power is unlikely to add greatly to function Voluntary power returns long before changes in electrical reactions, which cannot therefore be used to prophesy recovery

The Stage of Permanent Paralysis. There can now be no hope of further recovery although improvement in function is possible by hypertrophy of active muscles by trick movements or by the use of appliances Constant supervision is required to prevent deformity brought about by the over action of muscles which have no opponents, and tendons may need to be transplanted or joints arthrodesed.

Some new factors must be considered at this stage (*a*) *Vasomotor changes* The paralysed limb will be cold and blue. Chilblains and trophic ulcers may be a source of considerable pain. (*b*) *Shortening of limbs* In young children, growth of bones may be impaired and considerable shortening may result by the time growth has ceased This may amount to several inches and will tend to be greater when the disease has occurred at an early age and when the paralysis is severe (*c*) *Dislocation of joints* The shoulder and rarely the hip may dislocate when the surrounding muscles are paralysed.

Prognosis therefore is most difficult in the earlier stages. No one can tell exactly how much damage has been done in the cord nor how that damage will influence the limbs in the direction of ultimate paralysis or

cessation of growth. A prolonged first stage is often a precursor of delayed repair and a protracted recovery Fairly complete early paralysis of both lower extremities usually carries with it a bad outlook especially if persisting after three months.

Treatment of Poliomyelitis. This necessarily varies with the stage of the disease.

First Stage In this stage the essential treatment consists of rest and relaxation of paralysed muscles and relief of pain and spasm Nothing can be done to hasten or modify the recovery process in the damaged cord. The patient is placed on a firm level mattress. Paralysed muscles are relaxed by removable splints in the case of foot-drop or by abduction of the arms for deltoid paralysis. Similar principles are adopted for other muscle groups. Pain is best relieved by hot moist packs applied frequently to the tender muscles These are allowed to cool slowly before renewal. Care is taken that deformities of the spine are avoided by maintenance of a symmetrical position of the patient and expert nursing must be provided.

When relief of pain permits, gentle massage and joint movements are started. The greatest attention to prevention of joint stiffness and contracture must be maintained throughout. Massage is of value in the restoration of muscle tone and blood supply Its object is to stimulate and develop the weakened muscles without undue fatigue At first gentle friction alone is required, but later the deeper parts can be kneaded When the time comes for active exercise of the muscles, this must be carried out with the influence of gravity eliminated by means of slings or manual support Electrical stimulation is of limited value as it is impossible to employ it effectively in cases of widespread paralysis. Interrupted galvanic stimulation to the individual muscles is the best form to employ until sufficient repair has occurred to permit of response to faradic stimuli. Over fatigue of the muscles must not be permitted. However active exercises in a warm bath may be beneficial and swimming pool therapy plays a large part in treatment.

Second Stage Here the chief efforts must be directed towards the prevention of deformities the correction of any that have developed, and the restoration of muscular power and function. Careful study of the patient is necessary in order to determine voluntary power in individual muscles which should be charted for future reference.

In the prevention of deformity two factors are important the influence of gravity and the pull of strong muscles against weak. These factors must be counteracted as far as possible by appliances, or by operations to correct these tendencies. Thus, a drop-foot should be supported by a splint at night and a toe spring by day In the later stages of the disease, and in situations where there are no deforming factors present, these principles may be modified and splints may not be necessary In general, however weak muscles should be relaxed until hope of recovery has passed.

Third Stage The object now is to restore function, so far as is possible, by correcting deformities and stabilizing weak or flail limbs. Mechanical appliances are often needed but must be carefully devised in order to assist and not hamper movement by unnecessary weight Plastics may be utilized for the simpler cases, while for metal contrivances, duralumin can sometimes take the place of steel. Callipers for stabilization of the knee or foot are often required.

Operative measures are directed towards either the restoration of muscle

balance or to the fixation of a flail joint. (*a*) Tenotomy or fasciotomy In paralytic drop-foot contraction of healthy calf muscles may prevent dorsiflexion of the foot and tendo Achillis lengthening will be necessary (*b*) Tenoplasty or grafting the tendon of a healthy muscle into a paralysed one has a certain limited scope in this affection but requires careful evaluation of the possible improvement (*c*) Tendon fixation is of some value as a means of stabilizing a flail limb *e g* in paralytic drop-wrist but unless the tendons are fixed very near to the articular surfaces, and only short lengths employed as accessory ligaments, they are extremely likely to stretch subsequently (*d*) Arthrodesis or the fixation of joints is a useful procedure when instability is difficult to control It is especially useful in the shoulder when the scapular muscles are intact. The operation consists in a modified excision, the cartilage being removed from the ends of the bones. A flail foot can be stabilized by Dunn s triple arthrodesis of the subtaloid talo-navicular and calcaneocuboid joints. (*e*) Where the whole limb is flail and an inconvenience to the patient, because of severe trophic ulceration the question of sympathectomy should be considered but in the worst cases amputation may become necessary (*f*) A short limb can be compensated by a high boot but this is unsightly and especially in women leg equalization by operation, may be desirable. This may be achieved by lengthening the paralysed leg or shortening the sound one for technical reasons, the latter is to be preferred.

Spastic Paralysis

This type of paralysis occurs when there is a lesion of the upper motor neurone, between the cerebral cortex and the synapse with the anterior horn cell in the spinal cord. The site of the lesion may therefore be in the cerebral cortex, brain stem or motor tracts. The muscles, although weak in action have increased tone with lack of balance between opposing groups There is a tendency to flexion of joints rather than extension and in cerebral lesions the degree of deformity is increased by emotional stress on the part of the patient. Movements are inco-ordinated and function is seriously impaired Muscle wasting is slight, but some vasomotor changes may be present resulting in a cold limb although these symptoms are slight in comparison with those found in lower motor neurone lesions. The limb reflexes are increased and the plantar response is extensor The deformities can be corrected to some extent by firm manual pressure unless fixed by fibrosis.

Spastic Paralysis in Adults This may be a legacy of childhood, or acquired by disease of the central nervous system. Disseminated sclerosis is an example of a neurological disease which may cause severe flexion and adduction deformity in the lower limbs. A stroke or hemiplegia is another common cause and may be the result of a cerebrovascular thrombosis. Injuries to the motor area of the brain or to the spinal cord may also be responsible, while spinal tumours, and pressure from a tuberculous abscess of the vertebra (Pott s paraplegia), provide other well recognized examples of spasticity caused by disease.

Spastic Paralysis in Children. The paralysis may not be apparent in young babies although present from birth, but becomes increasingly obvious as the child grows. Backwardness or lack of normal mental development, may be the first sign to be noticed In older children attention may be drawn to the nervous system by an unusual gait.

Cerebral Palsy (*Little s Disease Cerebral Diplegia*) This is a group of conditions brought about by a variety of causes but bearing certain features in common Among these are a varying degree of impairment of intellect ranging from almost normal to idiocy emotional instability impairment of speech and spasticity of one or more limbs with inco-ordinated or athetoid type of movements. The affection may be asymmetrical or symmetrical. Three types are recognized.

(1) *Congenital Hemiplegia or Monoplegia* The cause may be a birth trauma, due to excessive moulding of the skull, with the result that the tentorium is torn and the brain compressed by a subarachnoid hæmorrhage. There may be a history of complicated labour In a few cases, an antenatal cerebrovascular accident (e g thrombosis) may be responsible

(2) *Acquired Hemiplegia of Children.* This may be caused by trauma to the motor area of the brain with or without an associated fracture of the skull. Thrombosis following an acute specific fever may occur particularly after pertussis Encephalitis is sometimes a complication of measles, while a hemiplegia may develop without obvious cause.

(3) *The Symmetrical Lesions Diplegia or Quadriplegia* These are most often caused by errors of development and there is no history of obstetric difficulties The intelligence may be severely impaired Anoxia at birth however is sometimes responsible especially in small premature babies. Severe cerebral damage can occur after only a short period of oxygen lack. Another cause is kernicterus due to Rhesus incompatibility

The characteristic deformities in the upper limb are flexion of the elbow pronation of the forearm and acute flexion of the wrist and fingers. In the lower limb flexion and adduction of the thighs flexion of the knees and equinovarus of the foot In less severe examples the main deformity may be confined to the knee and foot.

Treatment Assessment of mental capacity is an important preliminary to the planning of treatment. If the intellect is good much can be done by re-education of the paralysed limbs, using a combination of occupational therapy and physiotherapy The severely handicapped child is best treated in an institution devoted to the care of spastics.

In general, the use of splints and appliances is avoided as far as possible, but certain deformities call for their use. As an example, the acute flexion of the wrist and fingers may sometimes be greatly improved by fixation of the wrist in successive plasters, each correcting the deformity more than the last The improvement gained may call for an arthrodesis of the wrist in dorsi flexion to prevent relapse

Some reduction of muscle spasm may be obtained by operation. A simple example is the weakening of muscle action obtained by lengthening the tendo Achillis Muscle spasm may be diminished by the operation of neurectomy (Stoffel s operation). The principle of neurectomy is to divide some of the motor fibres supplying the muscle, so that tone is diminished. This can be done by excising a portion of the motor nerve trunk (e g the obturator nerve for adductor spasm) In the case of mixed nerves this procedure is undesirable owing to damage to the sensory fibres and the resection must take place at the point where the motor nerve divides to enter the muscle belly

Neurectomy is of little value in the upper limb but has a limited application in the lower limb when applied to the adductor hamstring and calf muscles

General Principles of Treatment of Deformities

A few general principles which govern orthopædic treatment may be mentioned here but it is obvious that space does not permit more than a brief account of these

Persistent Malposition. This may result in permanent structural changes Thus accommodative shortening of ligaments muscles etc. will take place on the flexor side of a bent knee or wrist while the structures on the extensor side will be stretched and in time from want of use will become atrophied Should the deformity be corrected the stretched extensors still remain weak or functionless The importance of this has been emphasized in connection with nerve lesions, whether traumatic or due to poliomyelitis Joints conform to this rule and the ligaments may become fibrosed or ossified if there is much damage, the deformity thus becoming fixed

Growth of Bone Development is controlled by the amount and direction of the forces and strain to which it is exposed Normal strain in a normal position means normal growth. Abnormal strain even in a good position may result in deformity especially if the general condition is poor but if time be allowed for repair and improvement of the general health the bony tissue may recover and become consolidated in the abnormal position, and the resulting bony tissue may be more solid and stronger than ever Thus in rickets the long bones often become bent but strengthening buttresses develop in the concavity of the bent bones and the final issue when repair has occurred is an abnormally solid bone Similarly the kyphotic spine of "hunch-backs" may become powerful and strong.

On the other hand, want of use and loss of function are very quickly represented in bony tissue by atrophic changes.

If by operation or otherwise, deformed parts can be placed in a normal position once again so that normal strains are brought to bear upon them a return to a normal structure may be expected. This latter desideratum is, however also governed by the age of the patient and the length of time that the deformity has lasted In young people all growth tends towards the normal but in older people the tissues do not respond so readily

Exercises. When a displaced part can be brought gradually into the normal position, exercises will develop the muscles which have become stretched, functionless, or atrophic, and as the normal position is more easily and effectively maintained the structures which surround it will return more exactly to the normal The use of remedial exercises and re educational methods is based on this fact It must always be remembered however that it is useless to develop only one group of muscles without consideration of their antagonists. Muscles in the body are always balanced and both groups must be capable of active functions if the movements of either are to be effective Physiotherapy is considered in Chapter 13

Operative Treatment. This is frequently required since the cure of deformities by position and exercises is often a slow process in young people and almost impossible in those who are older Structures which are too short, e g tendons, muscles, etc. may be lengthened, lengthened structures may be shortened and displaced parts put in good position so that correct alignment of limbs is secured It must again be emphasized that the correction of the deformity is only the start of the treatment the development of the part so as to secure normal growth of the various structures concerned is just as important.

The consideration of many orthopædic deformities has been or will be dealt with in other parts of this work but in this chapter it is proposed merely to discuss certain serious disabilities

THE NECK

Torticollis. Torticollis, or wry neck, is produced primarily by contraction of the sternomastoid muscle, although in old-standing cases the trapezius splenii, scaleni and other deep muscles of the neck, as well as the deep fascia, are affected. It is characterized by the affected side of the head being drawn down towards the shoulder while the face is turned towards the sound side.

Several types are described acute congenital, spasmodic and ocular

Acute Torticollis. This is usually the result of exposure to cold or to sitting in a draught, or to some sudden movement which results in a " cricked neck." *The onset is sudden with pain and tenderness of the affected muscles* The head becomes fixed by muscle spasm, in a position of rotation and lateral flexion. Torticollis may be secondary to acute lymphadenitis or cellulitis, or to inflammatory diseases of the cervical spine (pyogenic osteomyelitis or tuberculosis) and these conditions must be considered in the differential diagnosis, although usually with them the onset of the torticollis is less sudden.

The treatment of the acute condition should be general as well as local aspirin (acetyl salicylic acid, 300 to 1 000 mg.) for relief of pain, local heat to the tender muscles and later massage and exercises. Torticollis due to a sudden twist of the neck may sometimes be relieved by manipulation.

Congenital Torticollis. *Two clinical types may be seen* (*a*) *A transient* wry-neck associated with muscle spasm, which passes off in a matter of weeks and is possibly due to malposition *in utero* or to mild trauma at birth (*b*) A persistent deformity which becomes more apparent when the baby is a



FIG. 11 2. TORTICOLLIS.
The right sternomastoid muscle is contracted.

few weeks old and which, if untreated develops into a severe contracture of the sternomastoid muscle The other muscles of the side affected together with the cervical fascia will also be involved

The aetiology of this type is unknown and it is probably present before birth. The sternomastoid muscle is found to be the site of interstitial fibrosis and the fibrous tissue is mature. In about one fifth of the cases the contracture is preceded by the formation of a "congenital sternomastoid tumour A lump is noticed in the muscle during the first month of life and disappears before the baby is seven months old Histology of this tumour shows that it is again composed of mature fibrous tissue.

A genetic origin birth injury intra uterine ischaemia, have all been suggested as possible causes but none of these theories provides a satisfactory explanation There is little evidence in favour of the genetic theory the fibrous tissue is too mature for it to be the result of a recent injury and does not resemble that found after ischaemia of muscle in other situations.

Either the sternal or clavicular portion may be affected but more usually the whole muscle stands out as a tense fibrous band. In late cases the affected side of the head and face is atrophic and the hemiatrophy will be marked The measurement from the external canthus to the angle of the mouth is shorter than on the normal side, the cheek less full and the forehead flattened There may also be a compensatory curve in the dorsal spine.

Treatment Massage and manipulation may first be tried especially if the condition is seen early but the majority require tenotomy followed by remedial exercises and stretching.

Two methods of dividing the sternomastoid have been employed (*a*) The *subcutaneous* operation is a desirable proceeding, as it leaves no obvious scar but requires great care in order to avoid damage to the important underlying structures There is but little danger or difficulty in dealing with the sternal head, a tenotome being passed down to it beneath the skin and the incision made from before backwards the tension to which it is exposed suffices to draw it well forward out of harm s way The clavicular portion, on the other hand, should generally be divided through an open incision. (*b*) The *open* method obviates all danger but leaves a noticeable scar unless care is taken to suture the platysma separately when closing. The skin, about 1 cm. above the clavicle, is incised across the muscle, its anterior and posterior borders are defined and its fibres completely divided. Tense portions of the cervical fascia on its deep aspect may also be carefully cut across, keeping in view the importance of the underlying structures. The position of the head is then rectified, and for a time it is kept between sand bags, or fixed by plaster of Paris. After fourteen days, all fixation is removed and active exercises started. These should be continued for several months. Provided that operation has been performed before the child is six years of age, the facial hemiatrophy will gradually diminish as the child grows.

Spasmodic Torticollis. This condition occurs most frequently in women about thirty years of age in whom there is often a family history of insanity or nervous diseases, such as epilepsy etc. It is characterized by clonic spasms of the various muscles of the neck, especially the sternomastoid and trapezius, but the deep short rotator muscles are also affected in many cases The head is continually being twisted and jerked into a position of torticollis, but other movements are often associated with this. The cause

is some lesion of the nervous supply of the muscles, probably in most cases cortical. In a few instances irritation of peripheral nerves as by inflamed lymph nodes or dental abscess, may exert some temporary influence but the true spasmodic wry-neck persists in spite of the removal or cure of such causes. The prognosis is always very unfavourable, since, even if the localized spasm is cured by appropriate operative treatment, other parts are likely to become affected. These patients should be referred to a psychiatrist.

Ocular Torticollis. This type is due to an imbalance of the eye muscles the head being held awry as a compensatory mechanism. The condition should be suspected in a case of torticollis in which no obvious cause can be found.

Cervical Rib. This is a common deformity. It is usually bilateral, and arises most often from the transverse process of the seventh cervical vertebra, rarely from the sixth. It is cartilaginous at first, but as age advances becomes

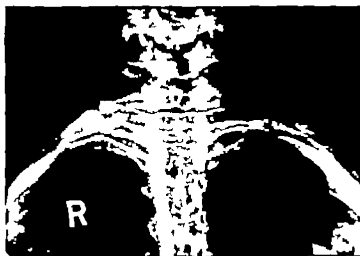


FIG 11 3 BILATERAL CERVICAL RIBS.
On the left side an articulation with the first rib can be seen.

osseous. The rib may be short, having a free end in the neck, or may be co tinued as a fibrous band to its attachment to the first rib in the region of t scalene tubercle. Occasionally it may gain attachment to the sternum, may consist of two portions, upper and lower united by a synchondros

The effect of the rib is to displace the trunks of the brachial plexus a subclavian vessels, upwards and forwards, so that the prominent subclavi artery may be mistaken for an aneurysm. The lower trunks of the ple derived from the eighth cervical and first dorsal roots are most often affect Symptoms, if present, usually appear in adolescence or in middle age, wh the shoulder girdle tends to droop. The symptoms may be nervous vascular. Pain, aching, numbness or tingling may be felt, usually along t ulnar border of the forearm and hand, but sometimes in the thumb ind or middle fingers. The intrinsic muscles of the hand may be wast Vascular symptoms are less common and may be due to arterial spas aneurysmal dilatation or thrombosis. Impairment of the radial pulse wh the arm is at the side, whiteness, blueness or gangrene of the fingers m

occasionally be present The possibility of the presence of generalized peripheral vascular disease must be borne in mind

A cervical rib may be felt as a hard swelling above the clavicle and can be easily recognized in an antero-posterior skiagram When marked wasting of the small muscles of the hand is present consideration must be given to other causes Among these lesions of the ulnar nerve progressive muscular atrophy rheumatoid arthritis and syringomyelia may be mentioned

No treatment is required unless symptoms are present when the cervical rib should be removed An alternative procedure is to divide the scalenus anterior muscle close to its insertion into the first rib This operation is more simple than that of removing the cervical rib and similar results are claimed for it

Brachial Neuralgia: Brachial Neuritis. These terms are used to denote pain radiating from the neck, along the nerves of the arm forearm or hand

The terminology is comparable with that of sciatica in relation to the lower limb being merely descriptive and not the name of a particular disease. To avoid confusion, it is better to speak of brachial pain which may arise in any of the structures of the arm or be referred along the nerves from the neck

If this pain arises in the arm itself the shoulder elbow or wrist joint may be at fault, or the cause may be found in the bones or soft tissues A common cause of brachial pain of this type is a lesion of the rotator cuff of the shoulder joint. Less commonly a metastatic deposit in the humerus may be found

When the pain is of the referred type and therefore arising outside the arm itself the cause must be sought in the region of the cervical nerve roots or in the brachial plexus.

It is doubtful if a true brachial neuritis can occur without the presence of some cause extrinsic to the nerve.

Pain Arising in the Cervical Nerve Roots The fifth sixth and seventh roots are most often affected. The usual cause is osteophytes or fibrosis in the neural foramina. The osteophytes are best demonstrated by oblique skiagrams. The lateral skiagrams show degenerative changes in the inter vertebral discs, but disc protrusions are less often the cause of root pressure. These degenerative changes seen in the intervertebral discs and diarthrodial joints are grouped under the general term *cervical spondylosis* It is important to realize that the presence of degenerative changes seen in the skiagram does not necessarily mean that they are the cause of the symptoms in a particular patient.

Pain Arising in the Brachial Plexus The eighth cervical and first thoracic nerves are those usually affected, and therefore the pain radiates along the ulnar border of the forearm and hand The nerves at the root of the neck may be subjected to stretching or pressure by several causes. Symptoms arising in this region may be conveniently grouped together under the title of *thoracic inlet syndrome* The cause may be a cervical rib a fibrous band, abnormal anatomy of the scalene muscles, or stretching of the brachial plexus over a normal first rib. This may occur when the shoulder girdle is depressed. Costoclavicular compression is of doubtful occurrence where these structures are normal. The symptoms, in most of these cases, can be relieved by exercises designed to improve the tone, in the muscles which elevate the shoulder girdle. The effect of a sling may be tried and the patient should avoid carrying heavy objects. Exploration of the brachial plexus should only be undertaken when conservative measures have failed to give

relief At operation it may be difficult to see exactly what structure is at fault. A cervical rib or fibrous band should be removed and in every case the scalenus anterior muscle divided.

Tumours Arising from the Apex of the Lung The so-called Pancoast's tumour of the lung, or a tumour arising from the first rib may involve the brachial plexus and sympathetic outflow which is shown by the presence of Horner's syndrome Pain, motor and sensory symptoms may be present in the arm

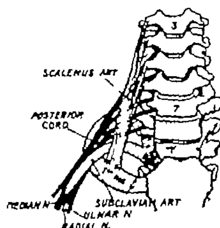


FIG. 11 4 THE RELATION OF THE SCALENUS ANTERIOR MUSCLE TO THE FIRST RIB.

Acroparæsthesia The symptoms are of numbness and tingling or discomfort in the tips of the fingers and thumb Women are affected more than men The onset may be during pregnancy but the complaint is most common in middle age.

The investigation of a case of acroparæsthesia must entail a thorough examination of the cervical spine, thoracic inlet and course of each nerve throughout the length of the arm. Special attention must be given to the ulnar nerve where it may be thickened or surrounded by fibrous tissue as it passes behind the medial epicondyle of the humerus.

Carpal Tunnel Syndrome It is convenient to describe this condition here. The median nerve may be the site of neuritis where it lies in the carpal tunnel at the wrist. In this region it may be compressed by the anterior carpal ligament.

In some patients it may be difficult to determine whether the trouble originates in the neck or at the elbow or wrist. In doubtful cases, the effect of wearing a sling by day or a splint to immobilize the wrist by night should be tried, before operative treatment is advised.

THE SPINE

Scoliosis

This condition is a lateral curvature of the spine. The thoracic, thoracolumbar or lumbar region, may be affected. There are two main types of scoliosis, *postural* (or functional) and *structural*.

Postural Scoliosis. This type is an error of posture which can be corrected by the patient by an effort of will. The curve disappears, on stooping to

touch the toes with the knees extended or on hanging by the hands from a wall bar. There is no deformity of the thorax. The curve may be to the right or left and extends over a considerable length of the spine, more commonly in the dorsal segment. Radiographs show no abnormality of the individual vertebræ. The condition occurs in children or adolescents and is associated with poor general health and muscular development. The child may be flat-chested, flat footed, suffer from adenoids, or recently recovered from one of the exanthemata. Faulty design of the school desk or defective eye sight may be responsible.

Postural scoliosis may be seen in those of low intelligence or pessimistic outlook. A depressed state of mind manifests itself in a relaxed habit of body. Hysterical scoliosis may be included in this category. A happy hopeful outlook on life tends toward an upstanding frame "with chest out and shoulders back."

Diagnosis. A survey of the general health must be made with special attention to the eyes, nasopharynx and neuromuscular system. General hypotonia of muscle may suggest organic disease. Correction of these abnormalities may be of more importance than the local treatment of the spine.

Treatment. These children benefit from a course of regular physical training preferably that provided by an out-of-doors school. Few ordinary schools find time in the curriculum for this important subject. Remedial exercises given three times a week under hospital conditions are a poor and time-consuming substitute for this régime.

Structural Scoliosis. The curvature cannot be corrected by a voluntary effort, nor by stooping or hanging from a bar. The more severe curvatures are always accompanied by rotation of the vertebral bodies, one upon the other. The degree of rotation between two adjacent vertebræ is small, but when a large number are involved the total effect is very marked. This effect is seen best in the thoracic region where the ribs, of necessity, rotate with the



FIG. 11 5. PARALYTIC SCOLIOSIS FOLLOWING ANTERIOR POLIOMYELITIS.



FIG. 11 6. IDIOPATHIC SCOLIOSIS. Note crowding of ribs, wedging and rotation of vertebræ.

vertebræ to which they are attached As a result, the whole thoracic cage becomes distorted, and the chest wall becomes prominent in front on one side and prominent at the back on the other side The direction of rotation is such that the spinous process moves toward the concavity of the curve, which appears less on clinical examination than on radiography Thus, in Fig. 11 5 the thoracic curve is convex to the right-hand side The effect of the rotation is to produce a hump most marked on forward flexion. The scapula overlying the hump will be displaced upwards and outwards. The distortion of the thorax may be sufficiently severe to cause displacement of the heart, lungs, or abdominal organs. Diminished vital capacity may lead to respiratory disease in later life The structural changes which prevent correction of the deformity take place in the soft tissues, which are contracted and in the vertebræ, which are wedge-shaped as can be seen in the skiagram (Fig. 11 6)

In the lumbar region, the effects of curvature and rotation are much less marked. The patient, if a woman may discover the deformity because of difficulty in fitting a dress. One hip is more prominent than the other and the waist line may be at a different level on the two sides "My hip is growing out" is a common complaint.

Classification of Structural Scoliosis. (1) *Congenital* This is present at birth, but may not be noticed at once The curve tends to be abrupt rather than gradual and may be limited to a short length of the spinal column

The condition is readily diagnosed by radiography This shows lateral wedging of the vertebral bodies, fusion, or an abnormal number of ribs, or the interposition of a hemi-vertebra on one side Other skeletal errors, such as spina bifida, may be present and the deformity may be very severe. On the other hand there may be little deformity and the tendency for this to increase during the growth period is limited compared with other types of scoliosis, in which progress may be rapid.

There is little that can be done in the way of treatment. The general principles discussed under idiopathic scoliosis may be applicable

(2) *Acquired* There are a considerable number of causes of origin

(*a*) Nervous origin. Paralytic *e g* poliomyelitis, syringomyelia and other neurological diseases.

(*b*) Muscle origin. Muscular dystrophies and myopathies

(*c*) Thoracic origin. Secondary to pulmonary fibrosis, with displacement of the thoracic viscera, and to collapse therapy for tuberculosis, *e.g* thoracoplasty

(*d*) Rickets. In countries where this disease is prevalent, it may be a cause of scoliosis.

(*e*) Due to pelvic tilt. Short leg or hip deformity will predispose and this variety is regarded as a compensatory scoliosis In the young it may be correctable if the primary condition is rectified. When of long duration, the scoliosis becomes fixed due to structural changes in the soft tissues and bones (Figs. 11 7 and 11 8)

(*f*) "Sciatic scoliosis" This occurs in the lumbar region and is due to muscle spasm associated with the protrusion of an inter vertebral disc. The deformity can be described more accurately as a sway or deviation of the spine to one or other side and is a position of maximum comfort.

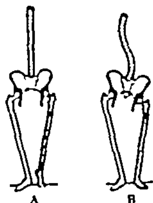


Fig. 11 7 Scoliosis Secondary to a Short Leg

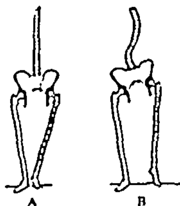


Fig. 11 8 Scoliosis Secondary to an Adducted Hip

(e) Idiopathic scoliosis The term idiopathic scoliosis is used to denote that the cause or causes are unknown The group is unfortunately a large one comprising about 85 per cent of all structural scoliosis. The curve may be noticed at any age between six to twelve years being common The deformity although slight at first may increase rapidly during the growth period especially so in the years between twelve and eighteen The association between scoliosis and neurofibromatosis should be remembered and search made for swellings or pigmented patches in the skin. The pattern of the curves varies. The primary curve is frequently to the right but when it



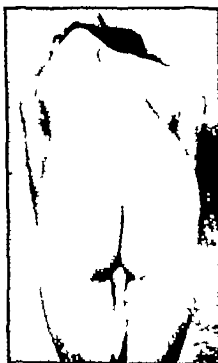


Fig. 11 9 Idiopathic Scoliosis in a Child of Eight
In the second picture the child is bending forward to show the "hump" caused by rotation of the vertebrae and ribs.

becomes more severe compensatory curves are developed above and below. Thus a triple curve may be present, the primary curve being to the right and the two secondary curves being to the left.

In order to follow the progress of the condition accurate records must be kept from year to year. Measurement of the angle of curvature may be made upon the radiograph and comparison of these angles forms a ready method of note keeping.

Scoliosis is said to be well compensated when secondary curves have developed in such a measure that the total effect is a reasonably straight spine. When the patient is clothed little deformity may be apparent.

Diagnosis of Scoliosis. The patient complains of the deformity and rarely of other symptoms, until later in life when pain may be experienced, due to secondary osteo-arthritis or to pressure on nerves.

It is most essential that a correct diagnosis be made as early as possib[le] of the type of scoliosis from which the patient suffers. The patient must b[e] examined completely undressed, except for short pants, so that the whole o[f] the back, position of pelvis and legs can be seen. Special attention is directed to the type and site of the curve present, presence or absence of a hump, shape of thorax and position of scapulæ. The inclination of the pelvis must be estimated with the patient standing to see if the line joining anterior superior spines is horizontal. The length of the legs must be measured and hips examined to discover any fixed deformity. The effect on the curve of

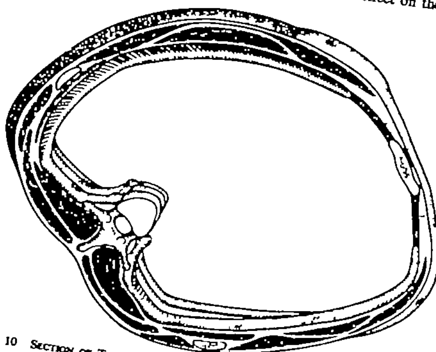


FIG. 11 10 SECTION OF THORAX IN A CASE OF SCOLIOSIS WITH THE CONVEXITY TO THE LEFT SIDE.

The rotation of the ribs and the distortion of the thoracic cage is shown.

stooping and hanging from a bar is noted With the patient lying prone careful estimation of muscle power should be made when the spine is extended voluntarily as it may be easy to mistake a mild paralytic scoliosis for the idiopathic variety The deformity in tuberculous disease of the spine is usually that of kyphosis, although a slight localized scoliosis may also exist. Radiographic examination must be carried out both in the lateral and antero-posterior planes and should include the whole of the spine The spine should also be radiographed in the positions of lateral bending to the right and left for by this means mobility can be seen From these films an accurate estimation of the angle of curvature must be made.

Prognosis The prognosis naturally varies with the cause of the scoliosis and the age at which it is first diagnosed Postural scoliosis responds well to exercises and attention to general health but when structural changes have taken place it may be difficult to decide whether the deformity is likely to progress considerably or remain stationary In the idiopathic variety once the deformity has become static, the best that can be hoped for is that it will remain so improvement in the degree of curvature is unlikely except by a surgical operation

Treatment of Scoliosis. The treatment of the secondary types of scoliosis depends largely on the cause of the condition. The paralytic variety commonly due to poliomyelitis, may improve considerably during the first year but after this time decision must be made as to whether the instability of the spine requires support by a spinal brace or whether fusion is necessary

The treatment of idiopathic scoliosis falls under two headings conservative and operative.

Conservative Treatment The aim here is to prevent an increase in the degree of curvature. Remedial exercises of various kinds have been used for many years for this purpose. In some cases the general posture of the patient may be improved considerably but comparison of radiographs taken before and after treatment show little if any change in the actual degree of curvature. It is probable that the curvature cannot be influenced materially by exercises.

The use of jackets or supports for the spine must be considered. In each it may be said that the function of a jacket is to limit movement and to prevent pain and hence they are most useful in the later stages where arthritic changes have developed in the joints, or where nervous tissue is compressed. It is doubtful if a thoracic curve can be controlled by the use of a jacket, although special jackets have been designed for this purpose. In the lumbar region better control is theoretically possible, but again it is doubtful if the degree of curvature can be influenced At the best the jacket may do no harm, but it tends to diminish mobility of the spine and to produce atrophy of muscles. In young children, the use of plaster beds in which the child can lie in such a position that the deformity is partially corrected, may be of value.

Operative Treatment is occasionally indicated in paralytic scoliosis or the idiopathic variety The indications are a rapidly increasing deformity which will be severe by the time growth has ceased, or in the case of paralysis, a flail spine which cannot be controlled by a support. Pain, nerve root or cord pressure, may also call for operative treatment. In brief the procedure consists first of correcting the deformity as much as possible by plaster jackets and when this has been achieved fusion of a considerable length of

serrati must be strengthened by massage, electricity and exercises, the latter necessarily directed towards extension of the back. Undue fatigue must be avoided, and the girl should rest on her back two or three times a day for half an hour. At night she should lie on her back, without a pillow and with a pillow beneath the curve. The general nutrition and health must also receive attention. In severe cases, rest in a *plaster bed* may be necessary for a few months, followed by a spinal support, when the patient is allowed up.

Lordosis. This is almost invariably a secondary or compensatory condition, and consists in an increased anterior curvature of the spine in the lumbar region. It is usually produced by continued flexion of the hip whether due to congenital displacement, unreduced dislocation, malunited fracture, or to hip disease and is irremediable unless the malposition of the femur can be corrected.

It is seen as a temporary condition in pregnancy and as a more persistent phenomenon in bad cases of uterine fibroids, owing to the increased weight of the uterus or its contents, necessitating backward displacement of the upper part of the spine in order to adjust correctly the centre of gravity of the body. The same may be noticed in persons with large, fat and pendulous abdomens.

It is occasionally present in progressive muscular atrophy where the lumbar and abdominal muscles are weakened, and usually in pseudo-hypertrophic paralysis from loss of power in the gastrocnemii and other muscles engaged in maintaining the erect posture.

Spondylolisthesis. This means literally a slipping of the spine. The fifth



FIG 11 13 SPONDYLOLISTHESIS IN A CHILD OF FOUR YEARS.
The zone of deficient ossification between the upper and lower articular facets of the fifth lumbar vertebra can be clearly seen.

lumbar vertebra slips forwards and downwards upon the sacrum or occasionally the fourth vertebra slips upon the fifth The cause may be found in an error of development of the pedicles a fatigue fracture in this region, or a fracture of the articular processes Erosion of the posterior articulations may allow a small degree of forward slip The exact cause is often difficult to ascertain with certainty

The possibility of spondylolisthesis being present should be considered in the differential diagnosis of low back pain or with pain radiating into the thighs. Symptoms may appear in young adults but are often absent until middle age

In severe cases there is a hollow above the sacrum which appears elongated (Fig. 11 13) Final diagnosis must be by radiography

Treatment Mild symptoms may be relieved by a lumbar corset. When spondylolisthesis is discovered in youth or when symptoms are severe the lower lumbar vertebræ should be fused to the sacrum by a posterior bone graft.

THE UPPER EXTREMITY

Congenital Elevation of the Scapula (*Sprengel's Shoulder*). The scapula is smaller than usual and is situated above its proper position (Fig. 11 14) The



FIG. 11 14 CONGENITAL ELEVATION OF SCAPULA.



FIG. 11 15 WINGED SCAPULA.

muscles attached to its upper border are prominent In a few instances a cartilaginous or osseous band has replaced them passing between the upper angle of the bone and the seventh cervical vertebra. The lower third of the trapezius is often defective, as also the serratus anterior The disability which is usually slight, depends on the condition of these muscles but the affected arm is sometimes smaller than its fellow The condition is often found in association with other congenital deformities in this region notable abnormalities of the vertebræ, causing scoliosis. Treatment by removal of the cartilaginous or osseous band is rarely indicated.

Winged Scapula This is a condition characterized by projection backwards of the vertebral border and lower angle of that bone when the arm is thrust forwards (Fig. 11 15). It is due to paralysis of the serratus anterior which normally keeps the scapula in contact with the chest wall. It may be due to injury or division of the long thoracic nerve in the axilla, as in radical mastectomy or to irritation and compression of the fifth and sixth cervical nerve-roots which may be tender weight-carrying on the shoulder may also be responsible for this lesion, and a neuritis due to infection has also been recorded.

Treatment The arm should be rested in a sling and the scapula strapped firmly to the chest wall. Faradism or galvanism may be applied to the paralysed muscle. In the absence of recovery some improvement may be secured by operative treatment designed to fix the scapula to the ribs, but the disability does not usually warrant this procedure.

Tilting of the Scapula. This curious condition occurs in children where the accessory nerve has been divided during operations on the neck, as for tuberculous glands. When the arm is raised or pushed forwards, the normal relation of the scapula to the spine is not maintained, owing to paralysis of the trapezius but the bone is tilted upwards and outwards, so that a considerable hollow develops immediately behind the clavicle. It is unsightly but not especially detrimental and with growth and active exercise any ill-effects usually disappear As a rule treatment is unnecessary but if need be an attempt must be made to find and unite the divided ends of the nerve

Cubitus Valgus and Cubitus Varus. Under normal conditions the axis of the forearm does not correspond with that of the arm the former being in a position of slight abduction (about 15°), constituting what is known as the "carrying angle" (Fig. 11 16 A) This angle is often greater in women than in men and when marked constitutes the condition of *cubitus valgus* (C). This is usually due to a fracture of the lateral condyle of the humerus in children. The damage to the epiphysis results in impaired growth Normal

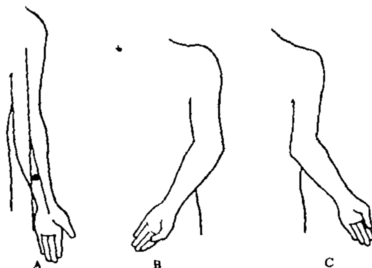


FIG. 11 16. CUBITUS VALGUS AND CUBITUS VARUS.
A. Normal carrying angle (angle *a* is 15°); B. Cubitus varus C. *Cubitus valgus*.

growth occurring on the inner side of the joint causes gradual increase of the carrying angle. Similar deformity may result from operative removal of the head of the radius. Occasionally a fracture of the medial condyle of the humerus with downward displacement of the fragment may cause cubitus valgus. The ulnar nerve is likely to become unduly stretched and by constant irritation to become swollen. Pain, paralysis and anæsthesia may result, the condition being termed *traumatic ulnar neuritis*. If the causative bony lesion cannot be repaired, the nerve should be set free and displaced in front of the condyle. *Cubitus varus* (B) is due to similar lesions of the medial or lateral condyle.

In rare cases a supracondylar osteotomy may be required to correct the deformity.

Madelung's Deformity. This is a condition more commonly seen in females and probably associated with injury. It consists of a retardation

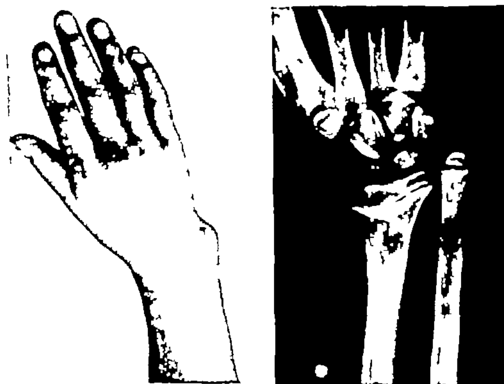


FIG. 11.17. MADELUNG'S DEFORMITY IN A YOUNG GIRL.
The child had previously sustained an injury to the radial epiphysis.

of the growth of the lower end of the radius whereby the carpus is pushed laterally by the ulna. The radio-ulnar joint is subluxated. It may be uni- or bi-lateral and is accompanied by a limitation of movement of the wrist joint, especially as regards dorsiflexion, and a weakness of all movements. Exercises and support by a moulded leather appliance extending the length of the forearm down to the metacarpophalangeal joints should be employed, or correction by operative means.

Clubbed Hand. Various types of malformation occur in which the hand is deflected to one or the other side, or is hyperextended or flexed. Perhaps

the most frequent cause is a *congenital absence of the radius* in which circumstances the hand is radially abducted to a marked degree, the ulna is shortened and curved and its lower epiphysis expanded so as to articulate with the carpal bones. Where the bones are normal, the hand is usually flexed and adducted towards the ulnar side. In all of these deformities radiography should be employed so as to ascertain the exact relation of the bones to each other Congenital absence of the ulna may also occur in which condition there is a manus varus deformity



FIG. 11 18. CONGENITAL ABSENCE OF THE RADIUS AND THE THUMB.

Congenital Deformities of the Fingers. These are common, and the account here given of such defects of the upper extremity applies with equal force to those which occur in the lower A family history of similar deformity is often obtained. The following varieties are described

Polydactyly This means the presence of supernumerary fingers and toes. There may be from one to seven additional digits, and the condition is usually symmetrical. The accessory digits are often stunted, and smaller in size than the normal but may be of average dimensions. Usually they are separated from the true digits, but now and then may be blended with them. The correct number of metacarpal or metatarsal bones may be present, or they may be multiplied. In one of our cases there were six digits and six metatarsal bones but the last two digits were supported by an accessory metatarsal apparently springing from the outer side of the fourth. The condition is frequently inherited. The treatment consists in removing the supernumerary digits, if useless, obtrusive, or troublesome. Sometimes the patients are proud of their abnormality and refuse to part with it.

Ectrodactyly The absence of one or more of the digits is occasionally seen, as also partial arrests of development of fingers or toes, or intra uterine amputation at a higher level.

Macrodactyly This is a congenital overgrowth of one or more fingers or toes The structures are perfectly normal in character and merely gigantic in size for the age of the individual. Amputation or excision may be needed in these cases, as the deformed parts grow out of all proportion to the neighbouring tissues. Thus, an infant with enormous overgrowth of the second toe of the right foot was successfully treated by excision of the digit,

together with a V shaped portion of the foot which was by this means reduced to normal shape and size

Syndactyly Webbed fingers is a condition in which two or more fingers are joined together laterally either by a thin web consisting mainly of skin or by a thick fleshy bond of union In the foot no treatment is required but in the hand the fingers must be separated If there is merely a thin web this may be divided by scissors, but to prevent its re formation as healing proceeds, a flap of skin must be transplanted into the angle between the fingers, or an opening in the base of the web maintained by a skin graft before the rest of the web is divided The raw surfaces left after division of the web must be covered by a thick skin graft

A similar condition is occasionally developed after burns or wounds involving the webs between the fingers It is usually preventable if the fingers are kept well apart and early skin grafting undertaken Otherwise



FIG. 11 19 SYNDACTYLY

the scar must be divided and the raw surface produced thereby grafted or alternatively operative treatment undertaken more or less similar to that described above.

Congenital Contraction of the Fingers This is a common deformity which is frequently inherited it is usually limited to the little finger and may be associated with congenital hammer-toe It is due to contraction of all the soft tissues on the palmar aspect of the finger whereas Dupuytren s contracture involves the palmar fascia itself and its *lateral* prolongations into the fingers. Moreover in the congenital variety the first phalanx is hyper extended, and the second and third flexed whereas in the acquired form the first and second phalanges are flexed and the third is hyperextended. It often suffices to use massage and apply a splint

Acquired Deformities of the Hand. After burns the hands may be contracted into a useless mass in which the fingers are drawn into the palm and united by cicatricial tissue to the palmar structures

Contraction of the Palmar Fascia (*Dupuytren s Contracture*) This condition is usually met with in middle-aged individuals, more frequently in men than women and often on both sides of the body It may or may not be associated with direct irritation of the palm, as by leaning much on a round headed cane, or from the constant use of some instrument, such as an awl, while heredity is an important causative factor Pathologically it is due to a chronic overgrowth and contraction of the fascia, inflammatory in nature

and cirrhotic or sclerosing in type. *It commences as an indurated subcutaneous* nodule in the palm of the hand about the situation of the most marked transverse crease, affecting most commonly the ring and little fingers first, the other fingers and thumb being much less often involved In some patients the induration appears to remain stationary for many years without much contraction of the fingers. In others, it spreads slowly both up and down the fascial bands into the fingers and may even extend downwards beyond the normal limits of this structure, so as to cause acute flexion of the *second phalanx, as well as moderate flexion of the first* The third phalanx always remains extended and indeed, sometimes assumes a position of hyper extension. The skin over the indurated aponeurosis sooner or later becomes incorporated with it and may be dimpled or creased About 25 per cent of

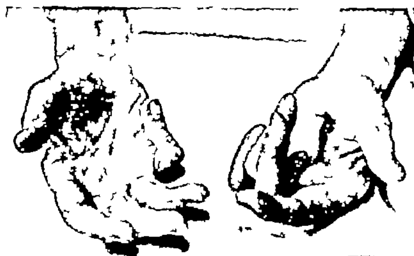


FIG. 11 20. BILATERAL DUPUYTREN'S CONTRACTURE.
The right fifth finger shows the typical flexion of the metacarpophalangeal and proximal interphalangeal joints and the hypertension of the terminal joint.

cases of Dupuytren s contracture develop a curious fibrous thickening over the proximal interphalangeal joints of the fingers. These knuckle pads are considered to result from the same pathological process which is responsible for the changes in the palmar aponeurosis. In both areas, trauma appears *to be an important factor*

The diagnosis of Dupuytren s contraction is easy The only conditions with which it is liable to be confused are (*a*) congenital contracture (*b*) flexion of the finger due to contraction, division or destruction *of the long* tendons (*c*) fixed flexion due to disease or injury to an interphalangeal joint (*d*) ulnar nerve lesions. In these conditions there will be a history of injury or disease but no induration or fibrous bands in the palm.

Treatment This is by operation which should, if possible, be undertaken before gross finger contraction or secondary changes have developed in the joints. If both hands are affected, the less severe one should be dealt with first. In severe cases the patient should be told that improvement, but not complete cure may be expected, because *the contracted joints* will prevent complete extension of the fingers. It may be wise to amputate a grossly deformed finger in order to obtain better function of the others.

The operation of choice is complete excision of the palmar aponeurosis through a wide transverse incision placed in the distal palmar crease. The fibrous prolongations into the fingers are removed through transverse incisions placed in the joint creases or through a Z plasty incision. A pneumatic tourniquet is used to obtain a bloodless operation field and complete hæmostasis must be secured at the end of the procedure. The hand and fingers are bandaged over a firm pad of wool placed in the palm but no splint is used. It is important to prevent œdema of the fingers by elevation of the hand for at least a week and by early movements. No stretching is attempted until the wounds are soundly healed but further extension of the fingers may be obtained subsequently by passive stretching or by intermittent splinting. Maintenance of free flexion is of more importance than the obtaining of complete extension.

THE LOWER EXTREMITY

Congenital Dislocation of the Hip

This condition is a dysplasia or lack of development of the hip-joint which is present at birth but may not be apparent until the child is several months old. Congenital dislocation has a geographical distribution being very common in Italy and certain parts of France but occurs sporadically in most countries. There is a hereditary trait in some families. Females are affected more often than males in the proportion of about seven to one. The condition may be unilateral or bilateral.

The whole joint is affected the most marked features being the shallow acetabulum small femoral epiphysis and dislocation of the joint. The degree



FIG. 11 21 ARTHROGRAM OF THE HIP JOINT IN A CASE OF CONGENITAL DISLOCATION OF THE HIP

The filling defect in the upper portion of the acetabulum shows the position of the in-turned limbus.

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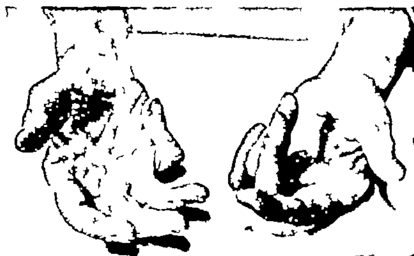


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FIG. 11 21 ARTHROGRAM OF THE HIP JOINT IN A CASE OF CONGENITAL DISLOCATION OF THE HIP

The filling defect in the upper portion of the acetabulum shows the position of the in-turned limbus.

of dislocation increases with age and becomes more marked when the child walks. Hence, it is unusual in this country for the condition to be diagnosed before the child is a year to eighteen months old.

In a skiagram the shallow acetabulum may be more apparent than real because the upper lip consists of cartilage in which ossification is delayed. The presence of this cartilage may be seen in an arthrogram as a "filling defect" (Fig. 11 21)

The floor of the acetabulum is occupied by fibrofatty material The capsule, which remains attached to the margin of the acetabulum and to the femoral neck, becomes stretched and elongated as the femoral head travels

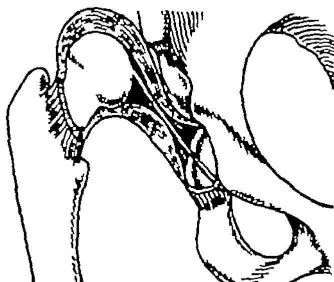


FIG. 11 22. DIAGRAMMATIC SECTION OF CONGENITAL DISLOCATION OF THE HIP SHOWING THICKENING OF THE CAPSULE AND LENGTHENING OF THE LIGAMENTUM TERES.

upwards on the ilium If the dislocation remains unreduced *weight-bearing* produces much thickening in the capsule, through which most of the strain is taken The ligamentum teres is similarly stretched and becomes adherent to the capsule (Fig. 11 22) The femoral head is late in ossification and if the dislocation remains unreduced, becomes distorted. Anteversion of the femoral neck is exaggerated and may be as much as 80° instead of the 35° usually present in an infant.

A false acetabulum may be formed above the true socket.

Diagnosis. Early diagnosis is of the greatest importance, if treatment is to be effective For practical purposes the symptoms and signs may be considered in two groups (*a*) infancy (*b*) after the child starts to walk.

Diagnosis in Infancy An observant mother may notice that something is wrong during the first few months of life. This is likely to be easier when the condition is unilateral because the lower limbs will be asymmetrical.

Asymmetry sums up the situation exactly One leg is shorter and smaller than the other and the difference in size may be noted by comparing the feet. The trochanter is more prominent because the femoral head is "standing away" from the acetabulum. This gives a rounded "female" contour on the affected side. Other asymmetrical features are the inguinal grooves,

labia and gluteal folds. On attempting to abduct the thighs widely the range of movement on *the affected side may be more limited In spite of* these signs, it may be difficult or impossible to be certain of the diagnosis in a fat baby

A skiagram may clinch the diagnosis but even with this aid doubt may exist unless the dislocation is complete In new born infants the femoral epiphysis is not ossified which adds to the difficulty

When the dislocation is bilateral, the upper parts of the thighs may not touch when the legs are held together The perineum may appear widened



Fig. 11 23 Unilateral Congenital Dislocation of the Left Hip
Note asymmetry of groin, prominent trochanter and short leg.



Fig 11 24 Congenital Dislocation of the Hip in a Child of Six Months.
The asymmetrical creases in the groins and the prominent trochanter can be seen on the left.

Other signs of dislocation are (*a*) *The femoral head is not felt in its* normal position in the groin but may be palpated through the gluteal muscles as it lies on the ilium When palpating in a normal groin, the femoral artery is easily felt pulsating between the fingers and the head of the femur If the head of the femur is displaced the pulsation is less easily felt. (*b*) *Telescopic movement When traction is applied to the leg, the trochanter* can be felt to move up and down

Diagnosis in the Child On walking the displacement of the femoral head is increased *The child will limp because the hip is unstable* and the limp will be painless In unilateral cases the gait is described as " lurching, but when both *hips are affected " rolling gait " is a more apt description* The instability can be demonstrated by Trendelenburg's sign which is positive. The test is performed as follows the patient is first made to stand on the sound leg and it will be seen that a slight normal lifting of the buttock, corresponding to a tilting of the pelvis, occurs. When the body weight is

supported by the affected limb the buttock on the sound side drops because the gluteal muscles are working at a mechanical disadvantage and cannot tilt the pelvis normally This sign is not diagnostic for dislocation of the hip joint, but occurs in any condition where instability of the joint exists.

Older children with unreduced bilateral dislocations develop an exaggerated lumbar lordosis (Fig. 11 25) This is due to the backward and



FIG 11 25 BILATERAL CONGENITAL DISLOCATION OF THE HIPS IN A GIRL AGED EIGHT YEARS.
Note the lordosis.

upward displacement of the axis of rotation of the hip joint which causes the pelvis to tilt forwards.

Radiography The points to note in the skiagram are the shallow acetabulum with its poor or absent bony upper lip The small ossification centre in the femoral epiphysis and the fact that the femoral head is not in the acetabulum The foreshortening seen in the femoral neck is due to anteversion.

Where doubt exists, four aids are useful

(1) Shenton s line This line is an elipse drawn through the lower border of the femoral neck and the upper border of the obturator foramen. In a normal hip it should form a smooth curve.

(2) Perkins s square. A horizontal line is drawn through the centre of the acetabulum and a vertical line dropped at right angles to it, from the outer lip of each The normal femoral epiphysis lies in the lower and inner quadrant (Fig. 11 26)

(3) The acetabular angle This is formed between the horizontal line and the floor of the acetabulum above it. It represents an index of the depth or shallowness of the acetabulum at the time of examination but is probably an unreliable measurement upon which to base prognosis.

(4) An arthrogram may reveal the "filling defect" produced by the cartilaginous upper lip of the acetabulum

Treatment of Congenital Dislocation The earlier this can be started, the better the chance of a normal hip joint Development of the acetabulum and femoral head can take place only when these structures are related to one another in a normal manner

The principle of treatment is therefore simple namely to place the femoral head in the acetabulum and to hold it there for a sufficiently long period so that normal development of both structures can take place

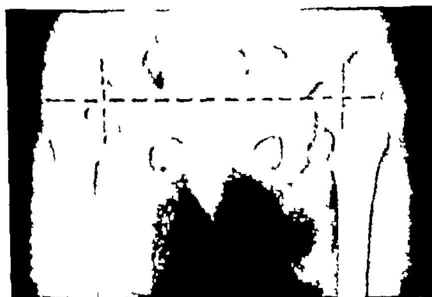


FIG 11 6. BILATERAL CONGENITAL DISLOCATION OF THE HIP COMPLETE ON THE RIGHT AND SUBLUXATION ON THE LEFT
The relation of the displaced femoral head to Perkins's square is seen.

The chances of attaining this diminish rapidly as age advances and after the age of three years success is unlikely without some form of supplementary treatment.

Treatment Before One Year of Age The legs are gently abducted if necessary under an anaesthetic and maintained in a position of full abduction flexion and external rotation (the 90 90 90 position) In small babies this may be achieved by thick napkins or by a pillow fixed in their place In older children a plaster of Paris spica or splint is required. The use of force may damage the femoral epiphysis resulting in avascular changes similar to those seen in Perthes's disease For this reason the Lorenz method, in which the adductor muscles were forcibly stretched and the reduction effected with a "click" has been abandoned

Treatment After One Year of Age It will not now be possible to abduct the thighs without force because the abductor muscles will be short and tight. The hip must be reduced by gradual traction Skin traction is applied to the limb and the pull should not exceed 4 lb (2 kg.) in weight. The child is placed on an abduction frame (Fig. 11 27) and the legs slowly abducted until 90° is reached. This may take from four to six weeks. At this time a skiagram is taken and if the hip is not completely reduced reduction is completed

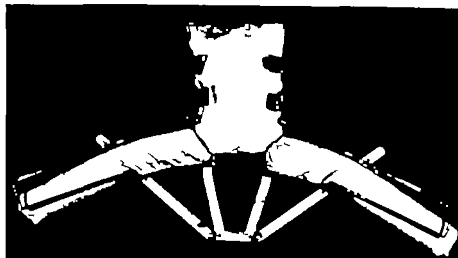




FIG. 11 27 ABDUCTION FRAME FOR CONGENITAL DISLOCATION OF THE HIP
Top The frame. *Bottom* The child in position. A sling attached round the left thigh is exerting traction on the femoral head.

under an anæsthetic and a hip spica applied the so-called frog plaster (Fig. 11 28).

The optimum position of rotation may be found under skiagraphic control and if much anteversion is present, the hip will be most stable in full internal rotation, a method advocated by Batchelor (Fig. 11 29) The period of fixation required will be from nine to fourteen months but a year may be taken as an average time.

The mother should be instructed in the management of the child before she is allowed to go home in plaster Considerable difficulty may be experienced in preventing the spica from becoming soiled The child should be supported in a semi-upright position so that urine does not run back into the plaster

Open Operation. This may be required in certain circumstances.

(1) If reduction of the hip is impossible by manipulation or traction, open reduction will be necessary At operation it will usually be found that the fibrocartilaginous limbus is turned into the joint and is compressed between the femoral head and acetabulum When this structure is removed

ull reduction of the hip is obtained After four months immobilization in plaster the child is allowed to walk

(?) If after a full period of conservative treatment the hip subluxates on weight bearing this will be shown in a skiagram which should be taken soon after weight bearing has started The recurrence of subluxation may be due to persistence of an inturned limbus to anteversion or to the imperfect development of the upper lip of the acetabulum The limbus should be removed An osteotomy to correct the anteversion or a bone graft to form a good upper lip to the acetabulum may also be advisable



FIG. 11 28 CONGENITAL DISLOCATION OF THE HIP
A child in a frog plaster



FIG. 11 29 BILATERAL CONGENITAL DISLOCATION OF THE HIPS.
A child in a Batchelor plaster with legs internally rotated.

(3) In children over the age of six in whom the hip is unreduced When the condition is bilateral it may be wise to do nothing Osteo-arthritis with pain may in later life necessitate treatment

In unilateral dislocated hip some form of reconstructive operation may be undertaken in order to stabilize the joint. A preliminary period of traction will be necessary to pull down the femoral head to the level of the acetabulum. In Colonna's operation, the capsule is detached from the acetabulum and is sutured over the femoral head which is thus enclosed completely The acetabulum is deepened with a reamer and the head enclosed in its capsule, placed in it. The early results of the operation are encouraging.

(4) In adults, operative treatment is undertaken for instability or for pain. Instability may be corrected by a Lorenz bifurcation operation in which an oblique osteotomy is performed at the level of the acetabulum and the femoral shaft displaced against the acetabular rim. When pain

occurs it is the result of osteo-arthritic changes in the false joint and therefore treatment is that of osteo-arthritis in general, either conservative or operative.

Other Deformities of the Hip

Coxa Vara. This is defined as a reduction in the angle which the femoral neck makes with the shaft. This is normally 120°–125° In severe cases the angle may be 90° or less. The patient may walk with a limp or complain of limited movement or pain due to secondary degenerative changes in the joint.

The clinical signs are prominence of the affected hip and true shortening of the femur which is localized to the region of the neck by the discovery of a raised trochanter (as shown by Nelaton's line or Bryant's triangle). Abduction is limited but the range of flexion will be full. *Trendelenburg's*



FIG 11 30 CONGENITAL COXA VARA AFFECTING THE LEFT HIP

sign may be positive owing to the fact that the abductor muscles are at a mechanical disadvantage.

The condition of coxa vara may result from congenital abnormality trauma, or disease in the epiphysis or neck of the femur

Raising of the trochanter may result from other causes such as dislocation of the hip joint, or destructive lesions of the head or neck of the femur (tuberculosis, osteomyelitis, or Charcot's disease) in which the *angle* of the neck is not altered. The causes of coxa vara may be conveniently considered under the following headings

(*a*) Congenital error (Fig. 11 30)

(*b*) Bone softening—Rickets, osteomalacia osteitis fibrosa, Paget's disease.

(*c*) Epiphyseal—Perthes's disease (osteochondritis) adolescent coxa vara (slipped epiphysis).

(*d*) Trauma—Fracture of the femoral neck, usually extracapsular where the neck joins the trochanter

(*e*) Senility

Epiphyseal Coxa Vara (*Slipped Epiphysis*) In this condition there is displacement of the upper femoral epiphysis downward and backward in relation to the neck of the femur as the epiphysis stays in the acetabulum

it is really the femoral neck which slips upwards and rotates outwards leaving the epiphysis below and behind it. Slipped epiphysis occurs most commonly in males about the age of puberty. There may be a history of pain or limp for a few weeks previously and this is sometimes followed by an acute crisis of pain brought about by some slight trauma such as jumping off a chair. Occasionally the pain is referred to the knee.

The cause of this condition is obscure. Often the patient is obese and appears to be under-developed sexually but many patients are of normal weight and development. It has been suggested that the underlying cause is probably an error in protein metabolism with chemical changes in the ground substance of the epiphyseal cartilage. In these circumstances the stress of normal activities is sufficient to displace the epiphysis.



FIG. 11.31. EPIPHYSEAL COXA VARA OR SLIPPED EPIPHYSIS.

On examination the limb will be held in flexion and external rotation. Pain is severe after a crisis and movement of the limb will be limited by muscle spasm. Some shortening may be present but this is not a marked feature.

The skiagraphic appearances are typical (Fig. 11.31). In the early stages, there will be slight widening of the epiphyseal line. The height of the epiphysis will be diminished because it is slipping backwards as well as downwards, relative to the femoral neck. For this reason a lateral skiagram must always be taken.

A ruler placed along the upper border of the femoral neck will not touch the femoral head as it does on the normal side. Shenton's line will be interrupted.

Treatment. Where the displacement is minimal the epiphysis is fixed by a trifin nail, or by several pins inserted along the femoral neck in the manner in which a fracture of the femoral neck is nailed. When considerable displacement is present, an anaesthetic is given and a very gentle manipulative reduction attempted. If this is successful, the epiphysis is nailed in



FIG. 11 35 GENU VARUM.
A case of severe rickets in a girl of fourteen years.

Genu Recurvatum (*Back Knee*). This deformity in which the knee joint becomes hyperextended, is usually seen in connection with severe paralysis, for example anterior poliomyelitis. When the quadriceps muscles are paralysed, the patient is able to gain stability of the knee joint only in hyper extension. In due course the cruciate and other ligaments become stretched and pain may result. The deformity may also be seen (*a*) as a congenital abnormality (*b*) as the result of damage to the anterior epiphyseal line and (*c*) when the joint is disorganized by Charcot s disease.

Treatment In paralytic cases control of the deformity may be obtained by the wearing of a knee cage or caliper Replacement of the paralysed muscle by tendon transplantation may occasionally be feasible

Deformities of the Tibia and Fibula. (1) Congenital bowing of the tibia may be anterior or posterior The condition is noticed in the first few months of life and the skiagram shows that the bone is not only bowed but is narrow at the apex of the deformity A pseudo-arthrosis may develop at [illegible]site and great difficulty may be experience[illegible] union, eve[illegible] grafting operations The ætiology is [illegible] the conditi[illegible] occasionally to be associated with neur[illegible] s and pigment[illegible] may be seen in the skin. In these [illegible] l bowing, [illegible] tibia is defective [illegible] the limb

(2) Outward bo[illegible] tibia [illegible] has mentioned in conn[illegible]

(3) Bowing, [illegible] or [illegible] seen in similar diseases in [illegible] are [illegible] 1 36). bowing is [illegible] legged with pressure [illegible] the [illegible] later life Paget s dr[illegible]

(4) Syphilitic periostitis laid down on the anterior surface of the tibia gives rise to the appearance of bowing (sabre tibia)

(5) Malunion in a fracture

It is to be noted that the anterior margin of the tibiæ in Paget's disease is thickened and rounded whereas in rickets it is narrow and sharp

Treatment Severe bowing in young people may necessitate correction

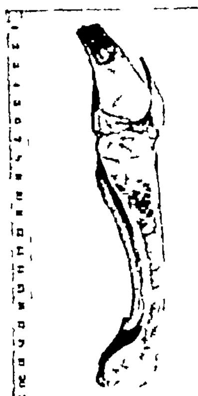


FIG. 11 36. RACHITIC DEFORMITY OF TIBIA AND FIBULA.

by osteotomy In the congenital variety of bowing, osteotomy is likely to be followed by non union unless bone grafting is done at the same time. Even under these conditions union may be difficult to obtain

Talipes

The Structure of the Foot. The chief functions of the foot are (*a*) to form a solid and firm basis of support for the body and (*b*) to permit elasticity and spring in the gait The foot may therefore be considered to consist of two parts (*a*) a posterior segment, or hind foot, consisting of talus and calcaneum, through which weight is transmitted to the heel and (*b*) an anterior segment, or forefoot consisting of the remaining tarsal and meta tarsal bones.

Mobility This is provided at three sites (1) The subtaloid joint provides a small degree of inversion and eversion of the calcaneum.

(2) The mid-tarsal joints, between the head of the talus and navicular and the calcaneum and cuboid, provide for inversion and eversion of the forefoot.

(3) The metatarsophalangeal joints, where flexion provides a rolling



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(2) Outward bowing of the tibia in young children has already been mentioned in connection with genu varum.

(3) Bowing, mainly at the upper or lower end, is seen in rickets and similar diseases in which the bones are softened (Fig. 11 36). The site of bowing is determined largely by the manner in which the child sits cross-legged with pressure on the bone in the region of the lateral malleolus. In later life Paget's disease is a common cause of bowing.

(4) Syphilitic periostitis laid down on the anterior surface of the tibia gives rise to the appearance of bowing (sabre tibia)

(5) Malunion in a fracture

It is to be noted that the anterior margin of the tibiæ in Paget's disease is thickened and rounded whereas in rickets it is narrow and sharp

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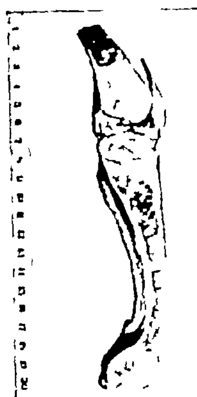


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(3) The metatarsophalangeal joints, where flexion provides a rolling

action, which takes place when the heel is lifted from the ground, as in walking

Elasticity This is provided by the arches of the foot. (1) The medial longitudinal arch (arch of the instep) is made up of the calcaneum talus navicular medial cuneiform and first and second metatarsal bones In a normal foot only the calcaneum and head of the *metatarsals are in contact* with the ground. The arch is maintained by the inferior calcaneonavicular or spring ligament, upon which the head of the talus rests and by the tendon of the tibialis posterior muscle with its prolongations to most of the tarsal bones. The plantar ligament, short muscles of the foot and plantar fascia also take part.

(2) The transverse arch is situated in the mid-tarsal region, and is really a half-arch whose inner end, which is the navicular is held in mid-air This arch must of necessity be lost when the medial longitudinal arch is flattened. It is maintained chiefly by the sling formed by the tibialis anterior and peroneus longus muscles

(3) The transverse metatarsal arch lies at the level of the metatarsal heads.

In a young person the first, second and fifth metatarsal heads make greatest contact with the ground and there is a slight hollow under the third and fourth heads The arch is maintained by the transverse metatarsal ligament and by the interossei muscles. When lost, a convexity is apparent under the middle of the arch and callosities may be present in the skin. Flattening of the transverse metatarsal arch is associated with the deformity of hallux valgus.

Varieties of Talipes. Talipes or *club foot* means a deformity *due to* muscular ligamentous or osseous causes, the deformity occurring mainly at the mid-tarsal joints, but all joints including the ankle may be affected Four primary types of talipes are described (*a*) *T equinus* in which the heel is drawn up the patient walking on the toes (plantar flexion) (*b*) *T calcaneus* in which the forefoot is drawn up and the heel is most prominent (dorsiflexion) (*c*) *T varus* in which the foot is inverted and the forefoot adducted the patient walking on the outer side and (*d*) *T valgus* in which the foot is abducted and everted The long arch is lost and may be in contact with the ground on walking. Mixed forms occur frequently thus T equinovarus or T calcaneovalgus

Talipes may be congenital or acquired

Congenital The congenital variety is often hereditary and may be found in several members of the same family it is sometimes associated with other deformities, such as spina bifida. It may arise from an error of development of some of the bones of the foot, or of the lower end of the tibia or fibula but probably it is more commonly due to malposition of the feet *in utero* induced by an unusually small uterine cavity or a deficient amount of liquor amnii, as a result of which the feet are abnormally compressed

Acquired. There are several varieties and these arise from some derangement of the equilibrium normally maintained between opposing groups of muscles, in consequence of which the more powerful group draws the foot into an abnormal position. Thus it may be due to

(1) *Paralysis* This may be flaccid as in infantile paralysis or lesions of peripheral nerves or *to a spastic paralysis as in cerebral palsy (Fig. 11 37).*

(2) *Cicatricial Contraction of Muscles* This may result from diffuse suppuration or trauma. Thus penetrating wounds of the calf muscle may

result in an equinus deformity while similar changes in the anterior or posterior tibial muscles may determine a position of varus

(3) *Diseases of Muscles* Progressive muscular atrophy is an example of this category

(4) *Compensatory Talipes* This may be present in patients with a short leg from any cause This is likely where the patient has not worn a high boot or other apparatus to adjust the length of the legs

(5) *Irregular Growth in the Epiphysis* This occurs most frequently at the lower end of the tibia or fibula Congenital absence of the tibia or fibula may be accompanied by severe talipes



FIG. 11 37 TALIPES IN A CASE OF SPASTIC PARALYSIS.

(6) *Prolonged Postural Deformity* Talipes decubitus or a fixed equinus position is sometimes seen in elderly patients after long periods spent in bed. The use of a bed cradle to relieve the foot from the weight of the bed clothes is essential, and sometimes a splint must be worn to maintain the foot at right angles. The following table indicates the chief diagnostic points between congenital and paralytic T equinovarus

	Congenital	*Paralytic*
History	Affection has existed from birth.	Affection not present at birth, and ushered in by convulsions, fever etc.
Feet Affected	Often bilateral.	More often unilateral.
Circulation	Good.	Feeble limb is sometimes cold, blue and clammy
Muscles	Wasting.	Extreme wasting.
Electrical Reactions	Not much impaired	Almost entirely absent in paralysed muscles.
Growth of Bones	Diminished.	Considerably diminished.
Creases in Sole	Present.	Absent.

before this happens, otherwise it will be impossible to cure the condition without resort to an operation on the bones. This should not be done, however, until the child is about ten years old or the growth of the foot will be impaired.

Bone changes. The neck of the talus is elongated and inclined medially. The navicular is displaced on to the medial side of the head of the talus, and it is this displacement which it is so difficult to correct. The shape of the other tarsal bones will be modified, as growth proceeds, being broad on the outer side and narrow on the inner to conform to the contour of the foot.

Treatment. This should be started as soon after birth as possible and certainly within the first two days. It should be explained to the mother that her co-operation will be required over a period of months, but that with regular treatment the condition may be cured.

The plan of treatment is firstly to correct the varus deformity and adduction of the forefoot and secondly to correct the equinus. The corrected foot should be of normal appearance and be capable of over-correction into the valgus position by light pressure on the outer border of the sole. The foot should be easily dorsiflexed to less than a right angle. Often the result of treatment falls short of this ideal. Correction is obtained by manual stretching carried out at intervals. The correction must be maintained by a splint, which is removed only for further stretching.

The heel of the right foot is grasped in the left hand, or vice versa. With his other hand the surgeon grasps the forefoot and stretches it into abduction and eversion. No anæsthetic is required. Care must be taken to protect the lower tibial epiphysis from injury. The manipulation is repeated several times and must be carried out firmly and deliberately.

A simple splint of malleable metal about the size of a tongue spatula, will suffice to correct the varus deformity. It is padded with felt and applied to the outer side of the leg by adhesive plaster. The foot is then pulled outwards and strapped to the splint in a position of valgus. A more satisfactory splint is that of Denis Browne (Figs. 11 41 and 42). The foot is attached to the sole plate first and then the vertical portion of the L-shaped splint is fixed to the leg so that the sole of the foot is everted. A splint is then applied to the opposite foot and finally the connecting bar is bolted on. The affected foot

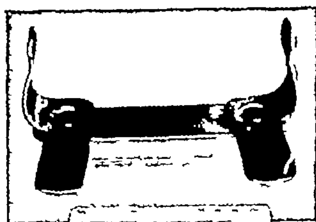


FIG. 11 41 DENIS BROWNE SPLINT
The felt padding is not in place.

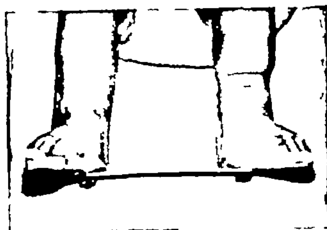


FIG 11 4? THE SPLINT APPLIED, SHOWING FELT AND STRAPPING.
The feet are externally rotated.

should be rotated outwards about 40° that on the sound side being in the neutral position. With careful application no undue œdema should be experienced The advantage of the splint over the use of plaster of Paris lies in the fact that the baby can kick The exercise prevents the leg muscles from wasting. Once a fortnight the splint is removed and the manipulation repeated Correction of the deformity of the forefoot may take several months and at the end of this time it is usually found that the tendo Achillis is also stretched sufficiently A tenotomy is seldom necessary

The second stage of treatment consists of maintenance of the correction by a simple splint of malleable metal, worn continually until the child is of walking age and then at night only The sole of the shoe should be raised ¼ inch on the outer side. The foot should be inspected regularly until the child is at least five years of age

Children of five or six months old in whom the deformity has not been corrected require stretching under general anæsthesia followed by plaster fixation. This may be repeated or open operation and division of the shortened soft tissues may be required The operation consists of division of the plantar fascia, the joint capsules of the subtaloid, talonavicular and navicular-cuneiform joints, on the medial side of the foot. The tibialis posterior tendon is also divided at its attachment. The foot is then put up in plaster for three to six months.

Uncorrected feet, in children of more advanced age provide a difficult problem. It is best to wait until the child is at least ten years old before operating. The operative principle is to remove wedge-shaped portions of bone from the adjacent sides of the subtaloid, talonavicular and calcaneo-cuboid joints in order to obtain correction of the deformity and then to fix the foot in plaster until bony fusion is secured Three to four months may be necessary for this. The result of such operations is often extremely satisfactory

Talipes Calcaneus. It is common to see babies born with this deformity and in many it is possible to dorsiflex the foot so that the upper surface makes contact with the shin. These feet are readily correctable by simple stretching of the contracted muscles and soft tissue. A straight splint applied on the anterior aspect to hold the foot in the equinus position for a few weeks is all

that is required (Fig. 11 43) A severe degree is rare except as an acquired deformity after infantile paralysis. Acquired talipes calcaneus is often associated with a valgus deformity calcaneovalgus, or pes cavus (Fig. 11 44). This is due to paralysis of the calf muscles which allow the heel to drop The talus is drawn into dorsiflexion by the unopposed extensor muscles, and the forefoot into plantar flexion by the short muscles in the sole

Treatment The treatment of the established condition is difficult. *Tendon transplantation or tenodesis of the tendo Achillis* may be possible,



Fig. 11 43 Congenital Talipes Calcaneus.

but correction may be achieved only by wedge resection and arthrodesis of *the talocalcaneal and mid tarsal joints.*

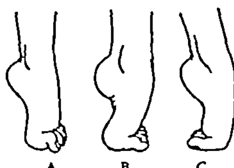
Talipes Equinus. This form of club foot is almost always acquired as a congenital lesion it is very uncommon (Fig. 11 45) It is a very frequent sequel of gunshot wounds of the muscles of the calf which have been followed by suppuration or required partial excision for gas gangrene cicatrization draws up the heel and brings about the deformity It also occurs as a compensatory manifestation where the limb has been shortened, *as after hip disease and may follow the prolonged pressure of bedclothes* on the dorsum of the foot of a bed-ridden patient (talipes decubitus). The paralytic form is the result of any lesion of the nerve fibres which control the anterior tibial group of muscles. If these are divided above the anterior tibial nerve the peronei muscles are also likely to be involved and the deformity has an element of varus added to the " drop-foot " which follows. The muscular involvement may be a little less regular in its distribution when resulting from poliomyelitis. In both of these conditions the equinus deformity is of the flaccid type.

In the slightest cases all that is noticed is that the foot cannot be dorsiflexed beyond a right angle (right angled contraction of the ankle) When more marked the heel is drawn up and the patient walks on the heads of the metatarsal bones and on the toes which are usually hyperextended but may occasionally become flexed (Fig. 11 45 C) so that in time the whole dorsum of the foot may even be turned downwards

Secondary changes occur in old standing cases The talus is displaced forwards from under the malleolar arch only the posterior part of the articular surface being in contact with the tibia In the paralytic type the anterior segment of the foot drops at the mid tarsal joint so that the head of the talus and navicular constitute a marked prominence beneath the skin In all cases the sole of the foot is liable to be shortened by contraction of the plantar fascia and of the short plantar muscles (pes cavus) and a certain



FIG. 11 44 ACQUIRED CALCANEUS DEFORMITY WITH PES CAVUS AND HALLUX FLEXUS.



A B C

FIG. 11 45 VARIOUS FORMS OF TALIPES EQUINUS.

amount of varus is frequently present. In this, as in all forms of talipes, callosities form over points of pressure and sometimes have bursæ beneath them.

Treatment If secondary to hip disease, the talipes should not as a rule, be corrected. When likely to develop as a result of intrinsic muscular contraction (post-suppurative or otherwise), it may be prevented by keeping the foot at right angles by a suitable splint, or in plaster of Paris. When fully developed tenotomy of the tendo Achillis may be required accompanied if necessary by division of the plantar fascia. In neglected cases, or where tenotomy has failed, excision of the talus gives excellent results, the patient being able to walk subsequently with a plantigrade foot.

In the paralytic variety whether central or peripheral, every effort must be made to conserve and render more efficient all muscular tissue that is capable of functioning. In old-standing cases of drop-foot with flaccid muscles and relaxed joints, operation to stabilize the foot must be considered and a triple arthrodesis of the subtaloid, calcaneocuboid and talonavicular joints is the most satisfactory means of securing this. The ankle-joint is not stiffened.

Talipes Valgus. This is usually the result of flaccid paralysis of the tibialis anterior and posterior muscles. The foot is everted the longitudinal arch lost and the head of the talus and navicular may be in contact with the ground when walking. Spasm of the peronei in cases of cerebral palsy may also cause a valgus deformity A rare congenital form results from absence of the fibula. The treatment depends on the cause

Other Deformities of the Feet

Pes Planus (*Flat Foot Splay-foot or Spurious Valgus*). This condition is frequently seen in all age groups. It occurs as a natural condition in certain negro races and is more often severe in the long thin type of foot. It is important to consider flat foot in relation to function. The complaint by a patient of "flat foot" may be one of appearance only and imply no disability

Flat-foot in Children. Advice is usually sought after the child walks. Examination should be general as well as local Appearance, intelligence and posture should be considered and the child should be completely undressed.

In the local examination of the foot, the gait, with and without shoes, must be noted When standing "tip-toe" the long arch is usually restored to normal The shape of the foot is observed and then the mobility Rigidity of the foot may be due to spasticity bony deformity or soft tissue contraction If the foot cannot be dorsiflexed above 90° contracture of the tendo Achillis is suggested. When standing, the heel will be unable to reach the ground unless the foot is splayed. The reflexes should be tested, and careful note made of muscle action to eliminate paralysis. Finally a skia gram may be required.

It must be remembered that flat foot may occasionally be secondary to congenital abnormality of bone or soft tissue, to spasticity or be associated with other deformity such as knock knee. The vast majority of so-called flat foot in children, however consists of a *postural deformity* of abduction and eversion, *i.e* valgus foot. The head of the talus is prominent and may be in contact with the ground. The foot is mobile and can be corrected by the child when standing "tip-toe." No obvious cause is found It is probably due to weakness or imbalance of muscles and in many cases is corrected as the child grows In a few the deformity persists into adolescence or adult life, and it is only after many years that symptoms appear from secondary changes in the ligaments and joints.

Most cases require no treatment, but an ⅛-inch wedge on the inner side of the heel will console the surgeon and appease the mother When the child can co-operate, exercises may be instituted and in severe or persistent cases a cork valgus insole may be justified Shoes should have a firm inner border to support the instep and should be of the lace rather than the strap, variety

Flat foot in Adolescence (*Spasmodic Flat-foot*) A few cases of postural flat foot may persist from childhood. In others the main features are those of a rigid foot in the valgus position with peroneal spasm Aching after exercise is the common complaint. The spasm is secondary to a tarsal arthritis possibly of traumatic origin or to congenital abnormality in the tarsal joints. X rays will help to decide which

Treatment consists in manipulation of the foot into the best possible position under an anæsthetic, followed by rest in plaster for several weeks. Recurrence of symptoms is likely If severe, consideration must be given to operative treatment designed to arthrodese the tarsal joints.

Flat-foot in Adults. This is often of acute onset—*acute flat-foot acute foot strain* The predisposing cause may be found in some illness such as an acute fever or the flat foot may follow a period in bed On getting up,



FIG 11 46. FLAT FOOT
The medial longitudinal arch is obliterated and the head of the talus is resting on the ground

pain in the feet is a prominent feature and may be accompanied by valgus deformity tenderness and œdema In other cases, the cause can be traced to a new occupation entailing prolonged standing, to which the individual is untrained as with nurses in training

Treatment should be preventive The bed patient has foot exercises before standing and should wear a firm shoe and not a bedroom slipper The young nurse or apprentice might well be trained in posture and muscle control.

In the acute stage rest to the foot is essential The patient is put to bed or in very severe cases the foot is put in plaster After a few days non-weight bearing exercises are started and no walking allowed until all pain has disappeared The shoe heels should be wedged ¼ inch on the inner side.

Flat foot of gradual onset may be symptomless at first, but pain is experienced when ligaments are stretched or arthritis develops. When muscle power is reduced the patient is unable to invert his foot when standing. Strain is thrown upon ligaments especially the calcaneonavicular or spring ligament, which supports the head of the talus. When stretched it allows the head to sink. This stage is painful—*chronic foot strain.*

Unless corrected the deformity may become fixed by fibrosis or arthritis (*rigid flat foot*)

Flat foot may also be secondary to infection, *e.g* gonorrhœa or trauma, *e g* fractures of the ankle and tarsus.

However produced the deformity when fully established is tolerably characteristic (Fig. 11 46) The sole of the foot is flat, and in well-marked cases comes in contact with the ground throughout the whole of its extent, as indicated by a print of the sole (Fig. 11 47) The inner border is convex and somewhat lengthened while the anterior half is everted and abducted. The head of the talus is felt a little in front of and below the medial malleolus. The sustentaculum tali, which is normally distinguishable about ¾ inch below the malleolus, is buried by this displacement. The tubercle of the navicular scaphoid is less evident than usual, being situated below and in front of the head of the talus.

In the early stages the foot may appear to be normal or merely a little everted when the patient puts no weight on it but when he stands, the

sinking of the arch becomes evident, and increased pain is produced. As the condition progresses, the front of the foot is more and more displaced outwards, and the talus sinks into the sole. After a time inflammatory troubles are lighted up in the joints, and adhesions form in and around them; or the deformity may become fixed by arthritis. In the early or first stage, therefore, the patient himself or the surgeon can easily restore the foot to a normal position; in the second stage, it may be possible for the surgeon to do so but probably only under an anæsthetic; finally in the third stage, when ankylosis has occurred, it is impossible to restore the arch except by operation.

The subjective symptoms are pain and a sense of weakness and fatigue, especially about the origin of the tibialis muscles, at first only experienced after or during exercise, but subsequently persistent. In the more acute cases pain is complained of in the sole and especially below and behind



FIG. 11.47. FOOTPRINTS OF HEALTHY AND FLAT FOOT

The raised arch of the instep in the healthy foot is represented by the hollow on the medial side; when the arch is exaggerated (*P. cavus*), this hollow becomes more distinct and may actually divide the print into two. In flat-foot it entirely disappears.

the tubercle of the navicular in the situation of the "spring" ligament; this may be very pronounced before the arch has actually given way. Later when the displacement is becoming more marked, pain across the dorsum is complained of over the talonavicular joint; when the displacement is still more severe pain on the outer side of the heel may become prominent, probably owing to the lateral malleolus impinging on the calcaneum. Often however there is but little pain when the arch has totally collapsed. Flat foot may be associated with hallux rigidus and this can be extremely painful.

Treatment. In the first stage, all that is required in the majority of cases is rest in bed for a few days followed by active exercises; by this means overstrained ligaments and muscles recover themselves. If the condition is of gradual onset, it may not be necessary to confine the patient to bed. The most important element in the treatment is the provision of suitable shoes, which should assist in keeping the foot inverted and thrown slightly over on to its outer border. The shoes should be low heeled and square-toed with the inner borders straight; the heel should be wedged upon the inner side ¼ inch, tapering off to the outer side and carried forward under the arch for ¾ inch further than is usual. All boots, shoes, and slippers must be similarly treated, and patients in the severe stages must not be allowed to put foot t

ground without this support The patient must be taught to walk with his toes straight in front of him with no trace of eversion Tiptoe exercises with the feet inverted are useful in strengthening the short muscles of the sole, as are also massage and electricity The latter may be employed in the form of faradic foot baths The feet are placed in a shallow bath of warm water which should just reach the instep The electrodes are arranged so that the current passing between them traverses the longitudinal muscles of the sole The anterior part of the transverse arch can also be treated by passing the current through the foot from side to side at the level of the metatarsophalangeal joints

When the affection has reached a later stage and the deformity cannot be remedied by ordinary manipulation forcible rectification under an anæsthetic may be employed The foot is firmly grasped in the two hands or in a Thomas's wrench (Fig 11 48) and the anterior portion is forced inwards

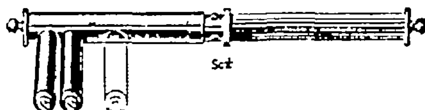


FIG. 11 48 THOMAS'S WRENCH

The two cross-bars are protected by thick indiarubber and can be approximated or separated by rotation of the handle. The anterior portion of the foot is firmly grasped between them, one being placed on the dorsal and the other on the plantar aspect, forcible wrenching movements can then be carried out.

and backwards in such a way as to draw the navicular round the head of the talus as a fulcrum, thus restoring the arch. Probably a number of adhesions in the talonavicular and other joints will be felt to give way during this manipulation Tenotomy of the peronei is sometimes required before rectification of the position is possible The foot is put in plaster of Paris and kept at rest for a week boots are then supplied and graduated exercise allowed Satisfactory results usually follow

When the deformity cannot be rectified by manipulation, and weight bearing is still a source of pain the patient may be advised to wear a carefully-fitted instep pad (fitted to a plaster cast of the foot) to assist in supporting the weight.

In a few cases with a fixed deformity operation on the bones may be justified. The removal of a wedge-shaped section from the inner side of the foot and the production of bony ankylosis between the navicular and talus is the only operative procedure worthy of consideration. Prolonged rest will be required subsequently while an arch support may still have to be worn.

Loss of the Transverse Metatarsal Arch. This is a frequent cause of sore feet when walking, may accompany pes planus or pes cavus, and is often associated with hammer-toes and hallux valgus It is due largely to loss of power of the interossei muscles. It is characterized by the heads of the metatarsals sinking so as to be brought into contact with the ground and as a result callosities form under them which are extremely painful.

It is often possible to press up the metatarsals into a normal position and to retain them there by pressure applied transversely around the foot just above the heads This can be utilized in treatment. A strip of chamois leather can be made to surround the foot in the position indicated and held there by adhesive strapping, or better an elastic band 2 inches wide can be worn around the foot with or without a pad of rubber placed centrally in the sole Shoes with bars across the sole as in Fig. 11 49B are also most helpful relieving



Fig. 11 49A. Valgus Arch Support
This is made of cork covered with leather



Fig. 11 49B. Metatarsal Bar, Useful in the Treatment of Metatarsalgia and of Hallux Rigidus and Pes Cavus.
The bar may also be placed on an insole worn inside the shoe.

he pressure on the painful metatarsal heads. Only when measures such as hese fail need the operations mentioned in the section on pes cavus be considered

Pes Cavus (*Hollow or Claw foot*) This is characterized by increased concavity of the plantar arch so that when the individual stands there is a greater interspace than usual, if not an absolute break between the impres sions produced by the anterior and posterior segments of the foot (Fig 11 50) Corresponding to the plantar concavity there is a marked dorsal convexity whilst the toes ar enerally clawed Tl f the metatarsal bones are unduly prom w and callosities beneath them, causing considerable p ondition is almc associated with a slight degree of talip right-angled co nd its method of production from this to be as follow ht is normally carried to the ground m the heel, b thr toes in these cases it is nly through fro foo ce the ante uscles are fle an advanta racting, d

so as to reach the ground so that the arch is increased Other factors may be (a) a familial tendency to a high arch (b) imbalance of the intrinsic muscles—interossei and lumbricals (c) contracture of the plantar fascia

In the later stages the foot becomes inverted and assumes a varus deformity the toes become blue contracted and painful and walking becomes almost impossible

Treatment In adults when the deformity is slight there may be few symptoms The addition of a metatarsal bar to the sole of the shoe is all that is necessary

In adolescents the prognosis is not so good so that it may be wise to attempt correction of the deformity Two types of operation are advised



FIG. 11 50 BILATERAL PES CAVUS IN A GIRL AGED THIRTEEN.

(a) Steindler's operation consists of division of the fascia and short muscles near their origin on the calcaneum followed by the use of a Thomas s wrench to flatten the arch The foot is then put up in a plaster for six weeks. (b) Lambrinudi s operation is designed to correct the claw toes by arthrodesis of the interphalangeal joints. The cavus deformity tends to decrease in the course of time A combination of both types of operation may sometimes be necessary Subsequently a metatarsal bar is worn on the shoe. Severe pes cavus in adolescents or young adults may require wedge osteotomy in the mid-tarsal region, with arthrodesis of these joints.

Hallux Rigidus. This is a painful condition of the great toe due to a chronic arthritis of the metatarsophalangeal joint. The joint cannot be extended and this causes pain on walking when the heel is raised from the ground The interphalangeal joint becomes hyperextended after a time. The condition usually occurs in young males and is associated with a long, flat foot. Hypermobility of the first metatarsal has been suggested as a cause of the flexed position of the toe adopted when walking. This is thought to be the cause of the arthritis which develops. Direct trauma is sometimes

responsible, particularly in adolescents. An example of this type is that occurring in young ballet dancers.

Treatment In the early stages, flat foot should be corrected. Shoes must be of adequate length and have a thick sole to prevent excessive dorsi flexion of the great toe Stiffening of the sole and the fitting of a metatarsal rocking bar usually gives relief but pain or osteophytic formation may call for operative treatment. The choice of operation lies between excision of the proximal half of the first phalanx (Keller's operation) or arthrodesis of the metatarso-phalangeal joint. The former is more usually advised.

Hallux Valgus. The great toe is displaced outwards from the axis of the first metatarsal bone. Anatomically this may be expressed as a deviation of the toe towards the midline of the foot. The toe is rotated so that the nail looks upwards and inwards. In severe cases small toes also take up a valgus position (Fig 11 51) A slight degree of the deformity is present in



FIG 11 51 BILATERAL HALLUX VALGUS.
Note the bunions. The toes are rotated so that the nails look upwards and inwards.

many adults and in a few children it may be seen about the age of puberty Causative factors are (*a*) *Heredity* (*b*) *Pressure from foot wear* Th design of women's shoes often bears little relation to the shape of the huma foot. This is a most important factor in the production of the deform and accounts for the fact that it is so much more common in women th men (*c*) *Anatomical*. Once a slight deviation of the toe has started, the oblique pull of the long flexor and extensor muscles tends to increase the deformity A further anatomical factor is that hallux valgus is nearly always associated with a broadening of the forefoot due to varus displacement of the first metatarsal. Osteo-arthritis and lipping of the joint with bunion formation are found in long standing cases. The bunions or adventitious bursæ may become infected

Treatment The treatment of hallux valgus in its earliest stages consists in the use of correctly-shaped shoes, with the inner border straight from toe to heel The introduction of a toe-post between the great toe and its neighbour is sometimes effective in giving relief

In young adults in whom no arthritis can be seen in a skiagram it is sufficient to remove the bunion with the underlying osteophyte or chondrophyte Where arthritis is present or where the deformity is severe an

arthroplasty should be performed A curved incision is made with convexity upwards, over the medial side of the joint The bursa is dissected out A flap, convex forwards is fashioned from the joint capsule and the joint exposed The exostosis is removed by a chisel

Two courses are now open to the surgeon (*a*) to remove the base and proximal half of the phalanx (Keller's operation) (*b*) to remove about five-sixths of the head of the first metatarsal (Mayo's operation) If this is done care must be taken to leave sufficient of the head to make a weight bearing contact with the sesamoids

After treatment consists in bandaging the hallux into the slightly over corrected position of adduction and flexion When the wound is healed active exercises and faradic baths are started but no weight bearing is allowed for three weeks An anterior metatarsal support must be fitted in the shoes, which should have square toe-caps and straight inner sides. A good movable joint results, though the toe is slightly shortened

Hammer Toe This deformity consists of hyperextension of the first

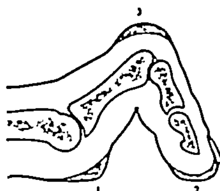


FIG. 11 52. HAMMER TOE
1 Callosity over head of metatarsal bone in sole 2, callosity over end of toe 3 callosity or corn over head of first phalanx.

phalanx, marked flexion to an acute angle of the second and either flexion or extension of the terminal phalanx. Callosities form upon the points of pressure (Fig. 11 52) especially on the dorsal aspect, and a subcutaneous bursa over the head of the first phalanx gives rise to great pain and inconvenience. The second toe is that most frequently affected, with or without the others, but it is uncommon for the hallux to be thus deformed The extensor tendons often stand out very evidently beneath the skin. The proximal interphalangeal joint may be subluxated and the joint capsule contracted preventing correction of the deformity except by operation.

Causes The deformity is occasionally congenital but more often acquired. When a single toe on each foot is affected the cause is obscure but when several toes are affected the explanation may be found in the wearing of shoes or socks which are too short. The term, claw toes, is applied to the latter group and is often associated with some degree of pes cavus

Treatment Surgical shoes built with a specially deep toe-cap may give relief together with regular chiropody If these measures fail, the hammer toe should be straightened by operation. The standard operation is arthrodesis of the proximal interphalangeal joint. After removal of the articular cartilage the toe is straightened and held in position by an intramedullary

formerly performed by transfixion in order to save time but the bulk of muscles included in the flaps, and the fact that the vessels and nerves are often sliced longitudinally render this an undesirable proceeding. Hence it has been discarded and the flaps are now usually marked out superficially and then raised by dissection. As a rule, they consist merely of skin, subcutaneous tissue, and deep fascia, a little muscle being perhaps included towards the base

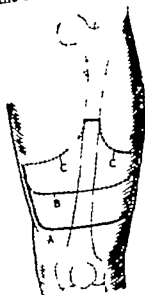


FIG. 12 1 AMPUTATION OF THE THIGH BY THE LISTER'S FLAP AND CIRCULAR METHOD.

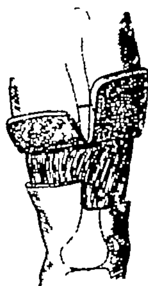


FIG 12 2. LATERAL VIEW OF THE SAME OPERATION WITH THE SKIN FLAPS DISSECTED BACK.

A indicates the anterior flap B posterior, which is half the length of the anterior C the line of division of the muscles, which is performed by circular sweeps of the knife.

The best method of amputating in muscular parts, such as the thigh, is that known as the *Modified Flap and Circular Method* (Figs 12 1 and 12 2), originally suggested by Lord Lister In this two rectangular flaps with the corners rounded off are raised on opposite sides of the limb, the length of the anterior being two-thirds of the diameter of the limb at the point at which it is proposed to divide the bone and the posterior flap half of the length of the anterior These, consisting merely of skin and subcutaneous tissues, are dissected up the muscles are then divided circularly being retracted for another half-diameter The advantages of the flap and circular methods are thus combined.

Amputation for Diabetic Gangrene. The gangrene may at first be dry but soon becomes moist and infected. The removal of a toe may suffice, but when there is infection spreading over the foot or into the leg, a major amputation will be required.

The classical site for amputation in these cases was above the knee in order to be well clear of infected tissue. This is not always necessary how ever and provided certain precautions are taken a below knee amputation will usually be successful Retention of the knee-joint is a great advantage to the elderly diabetic, even if an artificial limb is not worn The patient can more easily get in and out of bed, and sit in a chair There is also the factor of increased morale The below knee amputation may be through

infected tissue so that the wound must not be sutured The flaps must be short and not under tension Tourniquets should never be used when amputating for diabetic gangrene Occasionally in cases of diabetic gangrene it is possible to do conservative wedge resections of the forefoot, as far back as the metatarsal heads.

Silbert's technique is as follows. A circular incision is made 7 inches (17 cm) below the upper articular surface of the tibia and the skin and deep fascia reflected upwards for 2 inches (5 cm) The muscles are divided down to the bone at this level, and then dissected upwards and the tibia divided 4 inches (10 cm) below the knee joint The fibula is divided at a slightly higher level No sutures are used and the soft tissues are allowed to fall over the end of the bone and a Vaseline Gauze dressing applied. When the wound is inspected after ten days delayed suture may be undertaken, if there is no sepsis, otherwise it should be allowed to granulate When healed, the stump is prepared for limb fitting in the usual way

Pathological Changes in Stumps. *Infection of the Stump* This should not occur in amputations performed for disease or with unbroken skin, but in casualty work (civilian or military) where damaged or infected limbs have to be removed infection cannot always be avoided. It may be limited to a localized suppuration which merely requires the removal of a few stitches to effect drainage As soon as infection has ceased the flaps may be drawn together by strapping or closed by secondary suture In the more severe cases it is necessary to open up the stump freely When the infection has come to an end secondary suture is available unless necrosis has occurred.

Necrosis of the End of the Bone This is a frequent result of infection. A small annular sequestrum is usually all that separates but should the inflammation spread up the medullary cavity (acute traumatic osteomyelitis) a more extensive destruction of bone tissue follows.

In the milder cases there is little inflammatory reaction or pain, and all that appears is a sinus that will not heal. These cases should always be radiographed, and sequestra will often be found Operation for their removal should be undertaken at the earliest possible moment they usually become loose in from two to three months. Prolonged retention means increasing sclerosis of tissues and may necessitate re amputation.

Sloughing of the Flaps This may occur in debilitated individuals especially if thin skin flaps have been employed, or if their nutrition has been impaired by trauma or if unhealthy tissue has been incorporated in their substance by amputating too close to the seat of disease or injury The process is usually limited in extent, and rarely calls for treatment other than keeping the part dry and aseptic the slough being then slowly absorbed. If infection is present, the consequences may be more serious, even necessitating re-amputation at a higher level.

Changes in the Stump A *conical stump* results either from the flaps being cut too short, or from the parts shrinking as a result of suppuration, or in young people from continued growth of the upper epiphyseal cartilage of the divided bone. Rarely the bone may project through the integument and necrose re-amputation is the only treatment.

A *painful stump* is usually due to the adhesion of a bulbous nerve-end to the cicatrix or bone so that it is dragged upon at each movement of the limb The pain is of a severe neuralgic nature, and is treated by excising the bulb, or by re-amputation. In other cases it is due to the projection of a

this may be impracticable at any rate, it must be soundly healed before applying an artificial limb not adherent to the bone, with no tendency to eczema or ulceration, and not unduly sensitive.

The stump must be free from tenderness and able to stand a certain amount of pressure. The nerves divided during the operation follow the rules natural to these structures and develop bulbous ends. If these bulbs become adherent to the end of the bone or to the scar they are pulled on by every movement of the stump or are exposed to pressure and hence become a source of constant pain and disability The greatest care must be taken in amputations to divide all the main nerves high up

The after treatment of the stump is of paramount importance. Powerful muscles tend to produce contractures, and it is therefore wise to apply a splint for a time In a forearm amputation the elbow is likely to become

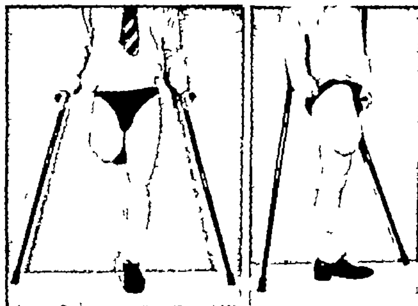


FIG 12 4 A PRIMARY CASE OF AMPUTATION ABOVE THE KNEE OF IDEAL LENGTH. The stump is very oedematous, and almost the same size as the natural leg. Binding and exercising, as described in the text, are necessary to prepare the stump for an artificial limb.

flexed and extension may be lost, unless the limb is kept for a time on a splint in an extended position and the elbow moved regularly The same rule applies to an amputation below the knee.

After the wound is healed the necessity for *proper care of the stump* can scarcely be over-emphasized. In the early stages after amputation, the greatest trouble the patient experiences with the fit of the artificial limb is caused by shrinkage and atrophy of the stump and it is therefore highly desirable to prepare the stump for the limb as soon as possible The time necessary varies with each individual for example, an elderly patient suffering from arterial disease will be weak, and it is advisable to wait four to six months before attempting to wear a limb on the other hand a youth who has lost his leg as a result of an accident will be strong physically and with proper treatment will probably be ready for limb fitting about six to eight

weeks after amputation For a patient to be left as so often happens eight months or so after operation with no treatment whatever is both prejudicial to the end results and a waste of time All cases should be exercised as soon as the wound is healed the patient should perform active movements against resistance two or three times a day for twenty minutes, a convenient stump exerciser can be procured in which the resistance is provided by elastics the strength of which can be increased progressively In this way the muscles are developed and superfluous flesh reduced It is possible to reduce a thigh stump 2 to 3 inches (5 to 7 5 cm) in circumference in four to six weeks by this means. At the same time mobility is retained and flexion and abduction





FIG. 12 5 FIG. 12 6.

FIG. 12 5 AN ELASTIC STUMP EXERCISER WHICH SHOULD BE USED PROGRESSIVELY IMMEDIATELY THE STUMP IS HEALED

The movements should be extension, flexion and adduction.

FIG. 12 6. THE CORRECT METHOD OF BINDING THE STUMP FROM BELOW UPWARDS, ALL THE FLESH BEING COMPRESSED AT THE BOTTOM OF THE STUMP

Comparison with Fig. 12 4 will show how much the stump is compressed by binding.

are counter acted A crêpe or rubber bandage will help to ensure even shrinkage. It should be applied firmly from *below upwards* to prevent the formation of a bulbous end of the stump which should be of an even slightly tapering shape.

The use of a temporary pylon is sometimes advocated A pylon is a temporary limb to enable the patient to walk, and thus to exercise his amputation stump It consists of a socket made of plastic material to which is fitted a wooden shaft ending in a rubber ferrule. No joint is provided, so that in an above knee amputation, the patient must walk with a stiff leg gait. A pylon is best made and fitted by a limb maker who is to fit the permanent artificial limb The stump must be carefully watched so that pressure sores are avoided.

opening the joint on the dorsal aspect, and cutting a palmar flap from the pulp of the finger

No useful result follows amputation through the proximal interphalangeal articulation, since the portion left is practically fixed and useless, no tendons being inserted to govern it. An operation which is sometimes advantageous consists in amputating through the middle of the second phalanx, so as to leave the insertion of the flexor sublimis tendon the flaps for such an operation are derived from any part of the finger and the bone is divided by bone cutters

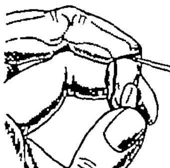


FIG. 12 7 INCISION FOR AMPUTATION OF THE TERMINAL PHALANX OF THE FINGER

Removal of a Finger at the Metacarpophalangeal Joint This is an operation frequently necessary It is best conducted by means of a racquet shaped incision which starts over the knuckle, extends between it and the next finger curves round to the palmar aspect so as to be placed a little below the crease in the skin at the root of the finger and returns in the same way to the back of the knuckle. This incision can be made with one sweep of the knife, but there is no real advantage in such a procedure. The articulation is then opened from behind the structures on either side are

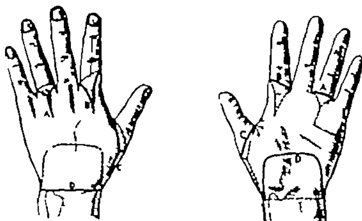


FIG 12 8. DORSAL AND PALMAR VIEWS OF THE HAND WITH INCISIONS FOR VARIOUS AMPUTATIONS.

A, Incision for amputation of finger by racquet method B, Farabeuf's method of amputation, as applied for index finger C, racquet-shaped incision for disarticulation of thumb at carpo-metacarpal joint D amputation through the wrist by a long palmar flap. In all of these the continuous black lines indicate the portions of the incisions visible from the dorsal or palmar aspects respectively the interrupted lines, the portions that are hidden.

successively divided making them tense by rotation of the finger and the flexor tendons finally cut across Bleeding points (digital vessels on each side) are secured, and the wound closed

The question of removing the head of the metacarpal bone is one which must be decided by the occupation of the patient If he is a working man or needs strength of hand it should be left as its removal always causes weakness. In ladies and those where smallness and elegance of hand are required rather than strength it can be taken away by slightly prolonging the incision upwards clearing the bone on either side and cutting it off The gap between the adjoining fingers can in this way be obliterated. It is especially advisable to do this in the case of the index finger since the head of the second metacarpal bone forms an unsightly projection and is very exposed to injury For this finger Farabœuf's method is often used When the finger is removed for severe infection it is often wise merely to dis articulate at the metacarpophalangeal joint and allow the sepsis to quieten down and the wound to heal by granulation. At a later date a neat re amputation including, if need be, the removal of the head of the meta carpal, may be successfully undertaken

Occasionally the four fingers and their attached metacarpal bones have to be removed *en bloc* Short equal flaps may then be cut from the front and back of the hand, and the disarticulation effected The stump that remains, although consisting of merely the carpus and thumb is very serviceable.

Amputation of the Thumb. Loss of the thumb seriously impairs the functional utility of the hand as large a portion must be saved as prac ticable, so as to assist the patient in grasping. The phalanges may be removed by any method which enables the bone to be covered with the least possible sacrifice.

When it is also necessary to take away the metacarpal bone, one of the two following plans should be adopted

The Racquet Method In this an incision commences in the inter tendinous hollow known as the anatomical snuff box, and extends along the dorsum of the thumb to the head of the metacarpal bone, the oval por tion sweeping round it at the level of the web when the thumb is abducted, and on the palmar aspect corresponding to the oblique crease at its root. The remainder of the operation resembles that for removal of a finger Care must be taken not to wound the trunk of the radial artery as it passes through the base of the interosseous space the blade of the knife is there fore kept closely applied to the bone.

By a Palmar Flap In this the knife is first carried across the dorsal aspect of the thumb, from the centre of the web between it and the index finger to a point on the palmar surface of the wrist just above the thenar eminence. The knife is then rotated so that its cutting edge looks outwards, and is made to transfix the ball of the thumb in front of the metacarpal bone, so as to emerge at the same spot in the centre of the web as that at which the dorsal incision commenced. A muscular flap with a well rounded border is readily fashioned by cutting outwards The remaining soft parts are then divided, and disarticulation is completed. It is a prettier operation than the former but otherwise has no advantage.

Amputations through the Wrist-Joint. These are seldom performed except for injuries, and are unsatisfactory from the prosthetic point of view the

operation is much preferable to disarticulation at the shoulder-joint. Care should be taken to prevent an adduction contracture of the arm, which is very liable to follow, and lessens the subsequent utility of the part.

Disarticulation at the Shoulder Joint. This is now usually undertaken by an anterior racquet-shaped incision. The third part of the subclavian artery may be controlled by digital compression, the surgeon endeavouring to leave the division of the main vessels until the last stage of the proceedings but it is perhaps better to clamp all the smaller vessels as soon as they are cut, and to isolate and tie the main trunks before their division. A preliminary incision similar to that for excision of the shoulder is first made, extending downwards and outwards through the fibres of the deltoid, from the coracoid process. This passes directly down to the bone, and if necessary the joint is at once opened and examined prior to any further steps being taken. The surgeon, standing on the outer side of the limb then carries his knife from the lower part of the incision downwards and inwards across the axillary folds around the limb to the point from which it first started, thus making the incision racquet-shaped. The skin is first dissected up all around for an inch or so and then the muscles on the inner side the deltoid in part, the pectoralis major, the coracobrachialis and biceps, are divided on the slant, thereby exposing the main vessels and nerves. The vessels may now be secured and divided, and the nerves isolated, pulled down and cut short, or they may be left intact till later The soft structures on the outer side of the vertical incision are next separated from the bone, and then the outer half of the capsule, together with the muscles inserted into the greater tuberosity of the humerus, and the long tendon of the biceps, are divided The inner half of the capsule and the subscapularis are then cut through so as to free the head of the bone. By retracting the external flap and protruding the head from its socket, the posterior part of the capsule can be severed, and then the knife, travelling downwards, between the humerus and the axillary vessels, is made to cut its way out, thus completing the disarticulation, the vessels and nerves, if not already dealt with, being divided as the last step in the operation. If the knife is kept close to the bone, the trunk of the posterior circumflex artery is not injured. Of course, an artificial limb after this operation has no functional value, but is merely ornamental.

Fore-quarter Amputation. Occasionally it is necessary to remove the whole of the upper limb together with the scapula and outer third of the clavicle usually for new growths. This so-called *interscapulothoracic amputa-*



FIG. 12 12. INCISION FOR THE INTERSCAPULOTHORACIC AMPUTATION.

tion is best performed according to Berger's method An incision is made along the clavicle and the middle portion of this bone is then removed so as to enable the surgeon to divide between ligatures the subclavian artery and vein on a level with the lower border of the first rib The anterior flap is then formed by an incision (Fig. 12 12) reaching from the centre of the

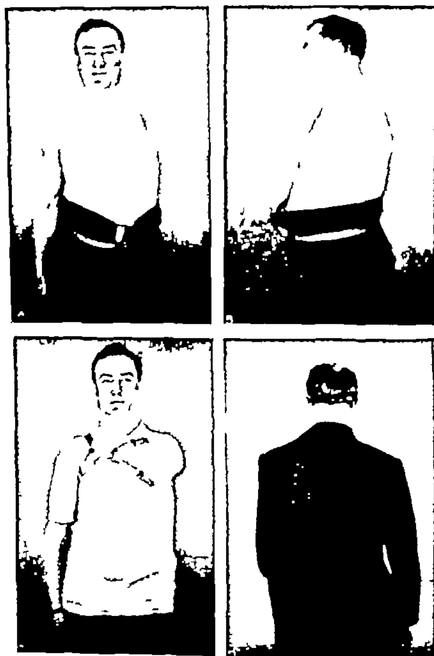


FIG. 12 13 FOREQUARTER AMPUTATION.

One of the results of this amputation is that the fitting of any appliance is extremely difficult, *for there is very little left* upon which to obtain a good grip. No form of artificial limb is practicable.

A, End result of amputation, B, side view C, protective covering applied D the squaring of the shoulder by the use of a protective covering.

former and extending downwards and outwards over the shoulder across the anterior fold of the axilla, and as far as the lower angle of the scapula. The pectorales major and minor are divided along this line, thereby exposing the brachial plexus the constituent nerves of which are severed on a level with the section of the vessels. The axillary space can now be opened up along the outer surface of the serratus anterior The limb is then rotated inwards and adducted across the trunk, and the patient drawn well to the edge of the table so as to enable the posterior incision which unites the outer ends of the two former to be made. The flap thus marked out is dissected up, and the different muscles retaining the scapula in connection with the body are divided one after the other including the trapezius omohyoid, levator anguli scapulæ, rhomboids, and serratus anterior These may be incised as near to the bone as is thought compatible with the total removal of the growth. Any remaining fibres are cut across, and the limb is thus detached. In cases of new growth there may be a large number of vessels, both arteries and veins requiring ligature

A limb-maker will supply a light protective covering which will square the shoulder and support the coat, though no form of limb is practicable.

Amputations in the Lower Extremity

Amputations of the Toes. Amputations at the metatarsophalangeal articulations are precisely similar to the analagous operations for the fingers. It must be remembered that the joint lies as far behind the web as the apex of the toe is in front of it, and hence the incision must start farther back than might be expected A solitary toe should never be left, as it always becomes troublesome, owing to lateral displacement this applies even to the big toe. The heads of the metatarsals should always be saved, if possible.

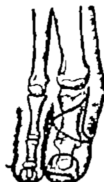


FIG. 12 14 FARABEUF'S AMPUTATION OF THE GREAT TOE.

For the removal of the great toe from the metatarsal bone, Farabeuf's operation is the best. The incision commences over the head of the latter bone, and well to the medial side of the extensor tendon it extends downwards nearly as far as the interphalangeal articulation, and then crosses the plantar surface of the toe so as to reach the centre of the web between it and the second toe thence the knife is carried straight back to the commencement of the incision. These cuts are deepened, the tendons divided, the joint opened, and the toe removed. It will then be found that an internal flap remains, which can be brought across the head of the metatarsal bone, and covers it in so that the L-shaped cicatrix is not exposed to pressure.

Amputation of the great toe at the tarsometatarsal articulation is conducted either by a racquet-shaped incision or by dissecting up a flap from the inner side It is a bad operation leaving an unstable foot and should if possible never be undertaken

Amputation of all the toes is occasionally required in severe cases of pes cavus The operation is best conducted by cutting dorsal and plantar flaps, which, after removing the toes, are united over the heads of the metatarsal bones.

Amputations of the Foot Several of these used to be performed—either at the tarsometatarsal articulation by Lisfranc s or Hey s operation and at the midtarsal joint by Chopart s operation These operations have been largely abandoned owing to the difficulty of fitting satisfactory appliances but are sometimes useful in the treatment of injuries or gangrene either senile or diabetic, in elderly subjects Success will depend upon the viability of the skin flaps which often retain a remarkably good blood supply

Syme s Operation Syme s amputation consists of a disarticulation at the ankle-joint together with removal of the two malleoli and the articular surface of the tibia. It is by far the best of all amputations in the neighbourhood of the ankle. The patient lies on the back with the leg well elevated

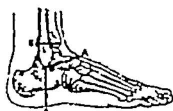


FIG. 12 15 LINES OF INCISION IN BONES AND SOFT PARTS IN A SYME S AMPUTATION.

A, A' Incisions for Syme s amputation S, section of the tibia and fibula.



FIG. 12 16. ELLIPTICAL INCISION IN A MODIFIED SYME S AMPUTATION.

and projecting over the end of the table, the surgeon standing either below or a little to the right of the patient. Having exsanguinated the limb the operation is, on the right foot, commenced by making an incision from the tip of the lateral malleolus down to the heel, and extending up to a point ½ inch (1 25 cm) below and behind the medial malleolus On the left side the incision is made in the opposite direction. For this purpose a short-handled strong-bladed knife should be employed (an ankle knife) The incision is directed slightly backwards, otherwise a bucket-shaped heel flap is formed, in which discharges may collect. The knife is carried down to the bone at the first cut, and the surgeon then proceeds to dissect up the heel flap thus marked out by inserting his thumb into the wound and partly peeling, partly cutting, the soft tissues from the back of the calcaneum. This is sometimes a tedious and tiring proceeding, since it is most important to keep close to the bone for fear of dividing the nutrient arteries of the flap, the lateral and medial calcaneal. The dorsal incision is then made, uniting the ends of the former wound, and carried slightly forwards so as to mark out a short convex flap This is dissected up and the ankle joint opened, the line of the articulation being placed ½ inch (1 25 cm.) above the tip of the medial malleolus. By division of the lateral and posterior ligaments, of the tendo Achillis, and of the few remaining fibrous connections along

the top of the os calcis, the foot is removed The lower ends of the tibia and fibula are then cleared and sawn off the ends of the dorsal flap being meanwhile held out of harm s way The main vessels are tied, as also any other bleeding points, the tendons and chief nerves are drawn down and cut short, and the wound closed by sutures, provision being made for drainage through one of the angles.

A *much quicker and prettier method of performing this operation* consists in making an elliptical incision and opening the joint and disarticulating, while the calcaneum is subsequently dissected out of the heel flap from above, keeping the knife close to the bone.

The modern practice is to cut the tibia and fibula about 1 inch (2 5 cm.) above the articular surface of the tibia. This is somewhat higher than the

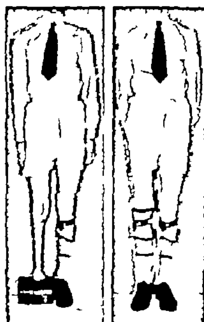


Fig. 12 17



Fig 12 18.

Fig. 12 17 Orthodox Syme's Amputation.

Note the great increase in terminal circumference of this stump The heel-pad is liable to loosen and become painful. The light metal limb fitted to this case is necessarily very much wider than the natural ankle.

Fig. 12 18 Syme's Amputation on a Bow-legged Patient

This photograph clearly demonstrates the difficulty of constructing an artificial limb with correct alignment.

old fashioned method but is desirable because it leaves sufficient room for a *mechanical ankle joint in the artificial limb there is less loose* flesh and therefore less likelihood of the end-bearing pad loosening and because the terminal increase in circumference of the stump is still great enough to be of value in holding the artificial limb in place, and is far less ungainly than when the bones are sectioned lower down

Syme s amputation has been condemned, more particularly by surgeons who gained experience during the first world war when many operations were performed in unfavourable conditions. A good Syme s will give excellent results, with the advantages that the patient takes weight on

skin already used to pressure and there is very little shortening, so that he can in emergency, walk *on the bare stump* It is contra indicated in cases where there is reason to suspect there may be circulatory trouble and in bow legged patients (Fig 12 18) and is not on the whole recommended for women because even the best appliance must be a little wider than the natural ankle.

Amputations of the Leg. These should be undertaken if possible 5½ inches (14 cm.) for a man and 5 inches (12 5 cm) for a woman below the articular surface of the knee-joint On a tall patient 1 inch (2 5 cm) longer than this is an advantage (Fig 12 19) A longer stump is not satisfactory because it does not allow of proper alignment of an artificial limb. In addition there is frequently vascular trouble Shorter stumps to a minimum of 2 inches (5 cm) of tibia though not ideal can give good enough results



FIG. 12 19 AMPUTATION BELOW THE KNEE, ALLOWING A LIGHT METAL LIMB TO BE MADE TO MATCH THE NATURAL LEG.

to make it well worth while saving the knee-joint. Almost any operation may be practised according to the needs of the case, but the most satisfactory is that by means of antero-internal and postero-external flaps, the former being the longer so as to bring the scar well behind After the first inch or two the flaps should be rapidly deepened so as to include all the muscles. In dividing the bones, care must be taken not to leave a sharp projecting edge *on the front of the tibia*. This is best prevented by partially sawing through the bone in an oblique direction from above downwards, and when this has reached a little beyond its centre, the saw is withdrawn and a horizontal section made, cutting across the oblique incision in such a way as to remove a wedge of bone from the front of the tibia, which thus becomes suitably bevelled. The fibula should always be divided before completing section of the tibia, and should be about 1 inch (2 5 cm.) shorter than the tibia, to leave a rounded end to the stump With short stumps it is not

advisable to remove the fibula *completely* as is sometimes advocated, because this alters the shape of the stump from triangular to circular and the triangular shape is extremely useful in helping to prevent an artificial limb from rotating.

Disarticulation through the Knee-joint. *This type of amputation is* useful when sufficient length of tibia cannot be retained. An end-bearing stump results, to which can be fitted a special type of prosthesis. The functional result is good.

Amputation of the Thigh. *This may be conducted by any of the general*

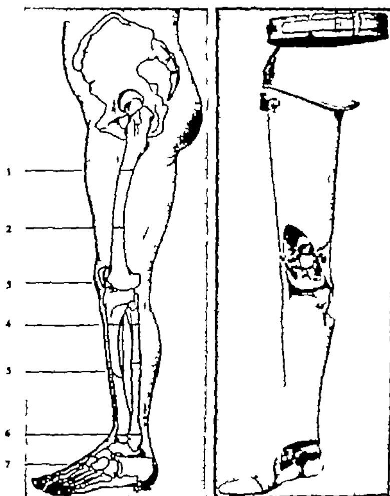


FIG. 12 20. AMPUTATION SITES OF THE LOWER EXTREMITY

An artificial leg is shown for comparison, demonstrating in section the space required for the knee and ankle mechanism.

1 Minimum of 3 to 4 inches of femur valuable for above-knee type limb, but every inch of bone above this very valuable for through-hip type. 2 Stump of 10 to 12 inches, measured from the great trochanter, is the most satisfactory 3 Amputations at or immediately above knee undesirable for prosthesis 4 Tibia 2 inches long, the minimum which can be used for below-knee type limb—in this case the fibula must, of course, be of equal length 5 Tibia 5½ inches long, with fibula 1 inch shorter gives best results in below-knee cases 6. Modified Syme's—very satisfactory in selected cases 7 All partial foot amputations undesirable for prosthesis.

The sites of amputation indicated in the diagram are necessarily only approximate (see text).

methods already described but Lister's operation modified flap and circular is the best

The length of femur varies according to the height of the patient but on an average 10 to 12 inches (25 to 30 cm) of stump measured from the great trochanter is ideal. With longer stumps not only do difficulties of circulation arise but there is not room for a mechanical knee-joint and the terminal increase in circumference of the lower end of the femur makes it impossible to fit a limb with a taper socket. Shorter stumps with as little as 3 to 4 inches (7 5 to 10 cm) of femur can be satisfactorily fitted with above-knee type limbs. Stumps with less femur than this have to be treated as cases which have been disarticulated through the hip and are fitted with the "tilting table" type of limb but it must be emphasized that even 1 inch (2 5 cm) of bone is valuable when it comes to fitting this type of limb (Fig. 12 21)

Disarticulation through the Hip-joint Formerly several different methods of operating were described but most of them are now discarded in favour



FIG. 12 21 AMPUTATION AT THE HIP

The shape of the stump shows clearly the value of saving even 1 or 2 inches of femur. The shape of the hip is retained, and provides a much better grip for the artificial limb than disarticulation.

of the anterior racquet operation. Of course it is occasionally necessary for some other plan to be adopted, but the surgeon must use his own ingenuity in devising this to meet the requirements of the case. No special means need be employed for securing hæmostasis, as the main vessels are tied in the early stages of the operation, and all others are controlled by pressure forceps as they are divided.

The incision commences over the centre of the inguinal ligament, and is carried down along the course of the main vessels for about 3 inches (7 5 cm.) The common femoral sheath is exposed and both artery and vein are secured by double ligature and divided. The incision is then completed: it sweeps over the inner side of the thigh 4 or 5 inches (10 to 12 5 cm.) below the

perineum to the back, and is brought up again to the front 3 or 4 inches (7 5 to 10 cm) below the great trochanter The muscular structures in the outer flap are then cut through, and the lateral circumflex artery and other bleeding vessels secured by arterial forceps *en route* By rotating the limb inwards, the insertion of the gluteus maximus can be divided as also the muscles attached to the great trochanter The muscles in the inner flap are then similarly dealt with after rotating the limb outwards, the medial circumflex artery etc., being secured. The capsular ligament is next divided transversely and the head of the bone disarticulated Finally the limb is rotated forcibly outwards, and all the soft parts at the back of the limb including the sciatic vessel and nerves, are divided from within outwards with one sweep of the knife The wound when sutured lies antero-posteriorly After this operation an artificial limb of the "tilting table type can be fitted and excellent results have been obtained (Fig. 12 21)

Hind-quarter Amputation. This operation, also called the inter innomino-abdominal, consists in removal of the whole limb and innominate bone of the affected side of the body Although a severe operation it has become a practical procedure, without undue risk, largely owing to the work of Gordon-Taylor The indications are (*a*) Primary malignant tumours of the pelvis and upper end of the femur (*e.g* chondrosarcoma) (*b*) Sarcoma of the soft tissues in this region and (*c*) Very occasionally for extensive tuberculosis of the hip and pelvic bones.

Careful pre-operative preparation is essential. This should include breathing exercises, elimination of sepsis as far as possible and correction of anæmia. In the theatre a self-retaining catheter is passed into the bladder which is emptied. Ample blood should be available for transfusion during and after the operation

The Operation A gluteal flap is used and the operation is performed in two stages An incision is made parallel and above the inguinal ligament and the abdominal muscles divided. Through this incision the tumour can be explored, and if operable the iliac vessels ligated. The pubis is divided by disarticulation at the symphysis. The gluteal flap is then fashioned by a posterior incision starting from the outer end of the anterior incision in the region of the anterior superior spine This incision runs backwards across the great trochanter to the ischial tuberosity and then forwards on the inner side of the thigh to the inner end of the anterior incision, in the region of the pubic symphysis The innominate bone is divided by a Gigli saw passed through the sciatic notch, or disarticulation through the sacro-iliac joint may be required

Division of the levator ani and pyriformis muscles, sciatic nerve sacrotuberous and sacrospinous ligaments will allow the half pelvis and limb to be removed. The wound is closed by suture of the gluteal to the abdominal muscles and by skin sutures Drainage is essential. After the wound is healed firm elastic support to the abdominal wall is required. This may be provided with wide crepe bandages or by a specially made abdominal corset. The majority of patients prefer to use crutches for walking, but a tilting table prosthesis can be fitted for cosmetic purposes

Chapter 13

INJURIES OF BONES AND JOINTS: GENERAL CONSIDERATIONS

Contusion of Bone

Contusion or bruising of a bone is usually a matter of no great moment, although the part becomes painful and swollen Occasionally a subperiosteal hæmatoma may ossify while if the periosteum is torn, osteogenetic cells may be set free from its under-surface and escape into overlying muscles, leading to new bone formation therein (traumatic myositis ossificans, p 177) Treatment consists in rest until the pain and swelling have subsided

FRACTURES

A fracture may be defined as a sudden solution of continuity in a bone usually resulting from external violence.

Predisposing Causes of Fracture. From two to four years, fractures are not uncommon owing to the unsteady gait and frequent falls to which little children are liable. Partial or "green stick" fractures are peculiar to the pliable bones of childhood During the period of growth until the epiphyses fuse to the diaphyses at about sixteen to eighteen years of age, an injury near a joint may cause displacement of the epiphysis rather than a fracture of the shaft. The maximum incidence of fractures is reached at thirty to forty years of age, and then diminishes until old age is reached when the incidence again increases because the bones become more brittle at this period of life

Sex As might be expected, fractures are more common in the male sex during boyhood and adult life, but up to the age of four or five they are equally frequent in the two sexes, while after forty-five they are more common in women, owing to their great liability to fracture the neck of the femur and to Colles's fracture

Morbid Conditions of the Bones These predispose markedly to what is known as *spontaneous fracture* in which the determining force cannot be recognized or is very slight. Under this heading may be included (*a*) Atrophy of bone, which may be of the senile type, as manifested especially in the femoral neck or is due to want of use, as in a paralysed limb or with an ankylosed joint. (*b*) Patients afflicted with certain mental or nervous diseases, such as general paralysis or tabes dorsalis are unduly liable to fracture, which may occur in apparently healthy bones. For instance, a man suffering from tabes was sitting with his thigh abducted and everted in order that he might examine and dress a perforating ulcer on the sole of the foot, when the shaft of the femur subsequently shown to be of normal dimensions, and apparently of normal density snapped in two (c) Osteogenesis imperfecta (see p 502) consists in an inherited tendency to spontaneous fracture.

Thus, a girl aged twelve and a half years had suffered from forty-one fractures since the second year of life. (*d*) General bone diseases, such as rickets and osteomalacia, also predispose to fracture in the latter affection the bones often bend considerably before breaking. (*e*) Local bone disease, *e g* cysts, sarcoma and secondary cancer may also be first recognized by a spontaneous fracture Hyperæmia in acute osteomyelitis may lead to a similar result.

Exciting Causes of Fracture. These are threefold (*a*) *Direct violence* the fracture occurring at the spot struck, being often transverse not infrequently comminuted and sometimes complicated by injuries to the adjacent soft parts. (*b*) When due to *indirect violence* the accident is usually produced by the compression or bending of the bone with such force as to exceed the limits of its natural elasticity so that it yields at the weakest spot. Thus, when a person jumps from a height, the leg bones are compressed between the weight of the body and the resistance of the ground and, if the violence is excessive, a fracture occurs at some point of mechanical disadvantage. If the stress falls chiefly on the shaft, an oblique fracture ensues, often with much longitudinal displacement and possibly becoming compound If an element of torsion is present, as by forced inversion or eversion of the foot, the fracture is likely to become spiral in type. If on the other hand, the violence expends itself on a mass of cancellous tissue, such as the calcaneum, talus, or upper end of the tibia, the bone may be fissured in various directions, comminuted, or even "pulped such a condition is sometimes termed a *compression fracture* (*c*) *Muscular action* is most commonly the cause of fracture of small bones or of osseous prominences, into which powerful muscles are inserted. The patella and olecranon are often broken in this way the former during sudden and vigorous efforts to avert a fall. Occasionally one of the long bones, such as the humerus or clavicle is broken by violent muscular exertion, as by throwing a cricket-ball.

Intra-uterine Fractures. Such fractures may result from blows upon the mother's abdomen, or from abnormal or violent uterine contractions, especially if the liquor amnii is deficient in amount, or if the formation of bone is defective as in osteogenesis imperfecta they are usually followed by considerable deformity *Obstetric fractures* occur during delivery and usually affect the shaft of the femur or humerus.

Varieties of Fractures

Closed (Simple) Fracture. This is one in which the skin remains unbroken

Open (Compound) Fracture. When the skin or mucous membrane is so lacerated that there is direct or indirect communication between the fracture and the exterior An open fracture is said to exist. In the base of the skull, a fracture may involve one of the deeper air-sinuses becoming open without any apparent external lesion.

Fractures are *incomplete* or *complete* according to whether or not the continuity of the bone is entirely interrupted.

Incomplete Fractures. Various forms are described and routine radiography shows them to be more common than would be supposed. A *greenstick fracture* (Fig. 13 1) is one which only occurs in young children Curved bones, such as the clavicle or radius, are most frequently affected, the fracture merely involves the convexity of the curve while the concave half

is bent, just as when a green bough or twig is partially broken *Depressions* of the skull may be similarly incomplete when the outer table is driven in without fracture and the inner table alone splintered *Fissured fractures* also are often only partial A *subperiosteal fracture* is one in which the periosteum remains intact although the bone is broken displacement does not occur and therefore the injury is likely to be overlooked



FIG. 13 1 GREENSTICK FRACTURE OF THE RADIUS AND ULNA IN A CHILD.

Complete Fractures. These may be *transverse* if due to direct violence *oblique* arising usually from indirect violence *spiral* when the force acts in a rotary direction as well as longitudinally They occur most frequently in the tibia or femur and the lower fragment often has a sharp triangular upper end, giving it somewhat the appearance of the mouthpiece of a clarinet (fracture *en bec de flute*). Not uncommonly a second fissure runs down wards from the main line of fracture, separating off a long narrow fragment of the shaft. A *longitudinal* fracture is one due to fissuring or splitting of the bone in its long axis, it is most commonly the result of gunshot injuries. If it is combined with a transverse fissure, it is often termed T-shaped. *Comminuted* is a term used to describe the condition when the bone is broken into more than two pieces *impacted* when one fragment is driven into the other *multiple* when more than one fracture exists *complicated*, when important structures such as an artery nerve, or joint, are damaged as well as the bone.

Fatigue Fracture (*March Fracture Pied Forcé* or *Stress Fracture*). These are most often seen in the second or third metatarsal bones, but occasionally occur in other bones such as the tibial shaft and shaft or neck of the femur Predisposing factors are (*a*) Undue fatigue of muscles and ligaments such as may happen in young recruits during a route march, (*b*) prolonged standing, (*c*) possible abnormality of the blood supply to the bone, (*d*) in the case of the foot, congenital abnormality of the first metatarsal, *i.e* unusually short (*metatarsus atavisticus*). An extra strain is thus thrown upon the second or third metatarsal. The patient is a young adult and gives no history of direct injury Pain has been noticed for a few days or weeks before advice is sought and there may be a swelling on the *dorsal* aspect of the metatarsal *neck* A *skiagram shows a spindle shaped mass of callus* a hair like fracture line, which is usually incomplete, may be made out with a lens (Fig 13 2)



FIG. 13 2. FATIGUE FRACTURE OF THE NECK OF THE SECOND METATARSAL. The typical mass of callus is apparent. No fracture line is visible.

Treatment This should be on general lines for a fracture in the foot. If pain is severe a walking plaster is applied, well moulded to support the *transverse arch of the foot. In other cases a felt metatarsal pad and strapping* may suffice. Later exercises to restore muscle tone should be given.

Separation of an Epiphysis. This results in young people from violence directed to the ends of the bones. The radius is the bone most often affected The line of cleavage usually runs through the soft spongy tissue on the *diaphyseal side of the cartilage, so that there is cartilage* with spicules of bone on one side and spongy bone on the other In very young children, where the epiphysis is entirely or mainly cartilaginous, the lesion is almost always a pure separation of the epiphysis from the shaft, but in older children it not unusually extends in part through the adjacent end of the diaphysis (Fig. 13 3). A *marked feature is the stripping* up of the periosteum which, though loosely attached to the shaft and easily separated from it is firmly adherent to the epiphyseal cartilage, and retains its connection with it thus frequently limiting displacement. If however the force is sufficient, the end of the shaft penetrates the periosteum, which grasps it closely and this

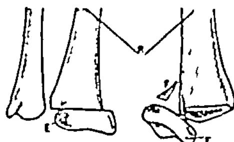


FIG. 13 3 SEPARATION OF THE LOWER EPIPHYSIS OF THE RADIUS.
E, Epiphysis R, radius F small fragment of bone from diaphysis.

periosteal " sleeve often hinders reduction Union usually occurs by means of bone, but arrest of the longitudinal growth may follow if the parts are not replaced in exact apposition This is a matter of importance when one of the bones of the forearm or leg is affected since deformity of the hand or foot results if the injured bone ceases to grow and the uninjured one continues its development as in Madelung s deformity (see p 215)

Partial detachment of an epiphysis (the *juxta-epiphyseal strain* of Ollier) often occurs, giving rise to phenomena similar to those of a sprain if neglected, it may interfere with the growth of the limb The essential feature is a more or less tender but very distinct, swelling of the bone close to the epiphysis, but the neighbouring joint remains unaffected Treatment consists in immobilization in plaster of Paris.

Signs of Fracture

The history usually given by the patient is that, as the result of some accident, he felt, or perhaps heard, something give way with a snap and experienced sharp pain which became much intensified on attempting to move the limb On examining the injured part and contrasting it with the opposite side the following points are usually noticed

(1) The *signs of local trauma* pain bruising and swelling as a result of the effusion of blood from the torn and lacerated structures. This may be so great as to obliterate all the ordinary bony prominences and landmarks. Blebs and bullæ sometimes appear over the surface after a day or two and must be carefully protected from infection The discoloration may spread by gravity to parts far removed from the original injury This infiltration often leads subsequently to considerable thickening and may produce adhesions and limitation of movement. It is unusual for suppuration to occur after a closed fracture, unless the patient harbours infection elsewhere in the body

(2) *Abnormal mobility in the continuity of the bone* may be demonstrated by manipulation, but never unnecessarily Impaction or non-separation of the fragments prevents its occurrence.

(3) Partial or complete *loss of function* also follows.

(4) *Crepitus* can only be felt when the fragments are movable and can be brought into contact, but not when there is wide separation, complete overlapping, or impaction. The term crepitus is applied to five different conditions which may produce a creaking or grating sensation to the examining hand. (*a*) *Bony* crepitus results from the rubbing together of the fragments in a fracture, or of the ends of bones in a joint when denuded of their articular cartilage. (*b*) A softer variety of bony crepitus is obtained when an

epiphysis is detached (*c*) An effusion of *blood* into the tissue gives rise to a soft crackling sensation on handling. (*d*) *Effusion* into tendon sheaths, bursæ and joints also causes a soft crepitant sensation, varying in different cases. (*e*) *Air* or gas in the tissue causes surgical emphysema and a characteristic form of crepitus

(5) Change in shape of the limb or *deformity from displacement* results from three chief factors the direction of the violence, the weight of the limb and the contraction of muscles, while injudicious movement or rough handling may aggravate it. Various types of displacement are described *Angular* generally due to the unequal action of powerful muscles *lateral*, where the displacement is merely to one or the other side, most common in transverse fractures *longitudinal*, when one fragment overlaps the other or is forcibly driven into it, causing shortening of the limb it may also occur in the form of wide separation of the fragments, as from contraction of the quadriceps in fracture of the patella *rotatory* when one fragment is twisted on the other as in fractures of the femur where the weight of the limb causes eversion of the lower fragment. In flat bones, *e.g* the skull, deformity may exist in the shape of *depression* or *elevation*

Radiography This is essential in the diagnosis and treatment of fractures. Although the diagnosis can usually be made on clinical examination, it is impossible to be certain in every case, unless skiagrams are taken. On medico-legal grounds alone they must never be omitted when a fracture is suspected. It is most important that the result of *reduction* of the fracture should be tested by radiography as thereby defects of alignment may be recognized and corrected early

A satisfactory diagnosis can never be made with the X-ray screen alone, the limb must be photographed in two planes at right angles to each other occasionally a *stereoscopic view* may be required It must also be remembered that all skiagrams are more or less exaggerations, varying with the proximity of the tube to the limb so that a deformity which is very obvious in the radiograph may in reality be comparatively slight. Finally one must not forget that callus is for a considerable time pervious to X-rays, so that, although the fracture is firmly united (*clinical union*) it may be still apparent in the skiagram. The fracture is said to be *consolidated* when calcification of the callus is complete.

General or Constitutional Effects of Fractures

Shock and Hæmorrhage. The degree of shock depends upon the character of the violence, site of injury damage to soft tissues and blood loss. Excessive laceration of muscle is associated with profound shock and sometimes renal failure. Blood extravasated into the soft tissues is lost from the circulation The presence of a wound in the skin merely renders this blood visible. It has been estimated that between 1 to 4 litres of blood may be lost in the tissues of the thigh when the femoral shaft is fractured. Another factor is that of excessive pain occasioned by movement of the limb when incompletely immobilized.

Fracture Fever Aseptic traumatic fever is met with in the majority of cases, commencing twenty four hours after the accident and lasting two or three days As a rule it is not severe the temperature rarely rising above 100° F in uncomplicated cases. In open fractures where asepsis has not

been attained any variety of wound infection may result even general septicæmia or pyæmia

Delirium. The onset of delirium may complicate the management of severe fractures. This is specially likely in the aged and the very young. Thus it may be seen in elderly women following fracture of the femoral neck who have been suddenly transported from their home to the unnatural surroundings of a hospital The characteristic features of this condition are those of mental confusion anxiety and disorientation in time and space The patient may think she is still at home or has just returned from shopping when in reality she has been in hospital for many days The symptoms are worse at night and the patient may become noisy Factors contributory to the onset of delirium are blood loss, shock dehydration alcoholism and previous arterial disease. Emotional factors may play a part and these are likely to be prominent after such catastrophes as fires, railway accidents and in battle casualties.

Treatment General treatment consists in the administration of adequate doses of hypnotic drugs, glucose and fluid by the mouth together with a light nourishing diet

The fracture should be managed in such a way that an early return home is possible. Failing this, the patient should not be kept in bed longer than absolutely necessary and should be nursed in an open ward with the company of other patients Isolation is to be avoided. Infection, bed sores and incontinence of urine or fæces, may make the nursing of these patients extremely difficult. Sepsis may be avoided by early wound toilet and the use of antibiotics. If established drainage must be provided Bed sores may be avoided by frequent change of position and skilled nursing. An indwelling catheter to prevent the soiling of bed clothes, may help to minimize the risk of these sores.

The use of the Smith-Petersen nail, which allows a femoral cervical fracture to be immobilized without the use of external splints, has considerably reduced the morbidity rate of this fracture. The patient can sit in a chair on the day following the operation can move freely in bed and sometimes return home in a few weeks. Such fractures when treated by plaster spicas or other splints, have a greatly increased morbidity rate

Delirium Tremens. This is a special form of delirium peculiar to chronic alcoholics. The precipitating causes are injury including fractures, and exposure. The classical example is that of the habitual alcoholic, returning home after a drinking bout on a cold night, who falls and injures himself and lies exposed for several hours before being found. The patient is anxious, sweating and trembling. Hallucinations are characteristic. Visions of reptiles, insects and pink elephants, from which the victim tries in vain to escape, may cause him to try to leave his bed, in spite of splints, extension or other appliances. The stage of excitement is followed by that of exhaustion, or coma may supervene

Treatment When the patient is known to be an alcoholic, it is important that his usual daily intake of alcohol should not be curtailed. Sudden withdrawal may precipitate an attack. When established, paraldehyde or morphine may be required in order to control the mania. Restraint should be as light as possible consistent with adequate control of the fracture.

Fat Embolism. This results from the absorption of broken-up fat globules after any injury which causes contusion or laceration of fatty tissue

when this is accompanied by tension from effusion of blood as in fractures, *this process is more likely to occur* *Usually* the greater part of the fat absorbed is filtered off by the lungs or eliminated by the kidneys and no harm results In fatal cases it can be demonstrated after death by staining with osmic acid The pulmonary obstruction may however become so great *as to lead to a fatal issue from dyspnœa, while if the cerebral vessels are* blocked, syncope or coma may be induced The symptoms are gradual in their onset and usually begin about the third day, but may not be evident for a week. This is a rare complication.

The Union of Fractures

When a bone is fractured the broken ends are left rough spiculated and more or less separated one from the other the periosteum is torn, but the rupture is not always complete, a "periosteal bridge containing osteoblasts perhaps persisting and playing an important part in the reparative process, especially if correct alignment is not obtained. The muscles and neighbouring tissues are lacerated, and a varying amount of blood is extravasated into them. In the course of a few hours after the parts have been immobilized the process of repair is inaugurated by the blood-clot becoming invaded by leucocytes, and after a time it is absorbed, the hæmoglobin passing through various stages of degeneration and thereby staining the surrounding tissues. At the same time all the injured and lacerated soft parts around become hyperæmic and the connective tissue cells therein proliferate actively Hyperæmia causes decalcification in the surrounding bone and enlargement of the Haversian canals. At the bone ends, some absorption takes place but contact is maintained by muscle tone *which approximates the fragments. Where internal fixation* by plates or screws has been used this approximation is prevented, and some delay of union will result because the gap has to be bridged by callus. The periosteum becomes thickened and more vascular and its connection with the bone is loosened for a short distance on each side of the fracture. Thus the whole area of the lesion is converted into a cellular mass, in which a gradually diminishing amount of blood-clot is present. This is vascularized from the tissues around and after passing through a stage practically identical with the granulation tissue of the soft parts, is converted into soft vascular bone known as *soft callus* or osteoid The ossification of the vascular and cellular exudate is always determined by the activity of osteoblastic cells, derived either from the damaged bone or from the periosteum. Wherever these travel they retain their bone forming potentialities. Hence ossification of the cellular exudate *is rapid, as it can be carried on from many foci.*

The soft callus or osteoid is converted into permanent or *hard callus* by the deposition of calcium salts derived from the local bone. This process may not be complete for many months and may be delayed by various factors.

The process of union can be summarized thus Blood clot invaded by connective tissue cells and vessels is converted into fibrous tissue, which in turn becomes osteoid by the invasion of osteoblasts. The deposition of calcium salts converts osteoid into hard bone. The time which this takes varies from a few weeks to many months and the process may be arrested at the fibrous stage (fibrous union) or calcification of the osteoid may be delayed.

Callus. Callus is formed in three situations.

External Callus The amount of external or ensheathing callus depends on the alignment of the fragments being greater where there is malposition or when movement can take place at the fracture site (Fig 13 4)

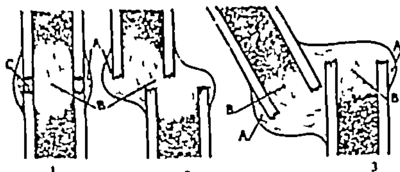


Fig. 13 4 Diagrams to Represent the Union of Fractures 1 when the Ends are in Close Apposition 2 when the Ends are only Partially Apposed and 3 when the Fractured Surfaces are not in Contact at all.
A, External or ensheathing callus B, medullary plug or internal callus C, definitive or permanent callus.

Medullary Callus This is formed solely in the medullary cavity When the bone ends are displaced this callus merges with the external callus, but if the bone ends are in continuity a plug of new bone occupies the medulla. It will be absorbed in the later stages of union and the medullary cavity will be restored

Definitive Callus Permanent callus is formed between the compact bone of the two fragments and constitutes the final bond of union.

A fracture is said to be united when no mobility can be obtained and when there is no pain on applying stress to the bone (clinical union). It is consolidated when calcification is complete as seen in a skiagram. The first change to be observed in a skiagram is that of decalcification, the result of hyperæmia, which may be apparent after three or four weeks. The appearance of calcification in the callus is variable being seen within three weeks in the case of an infant, but sometimes only after many months in adults.

It will be obvious that the continuity of a bone is restored long before repair is completed, and that it mainly depends on the ossification of the ensheathing callus, the amount of which is to some extent proportional to the degree of mobility and position of the fragments The formation of cartilage often occurs in the process of bone repair especially in young people, and where there is much mobility it is present chiefly in the early stages and mainly in the ensheathing callus. The newly formed osseous tissue is at first soft and spongy but gradually becomes denser at first it is easily detachable from the underlying bone, but later on is continuous with it. As the so-called definitive callus increases in strength the ensheathing callus is absorbed by osteoclasts and finally if the ends are in good position may vanish entirely while the medullary plug may also be totally removed Thus it is possible for the bone, in these circumstances, to be restored so absolutely as to show no signs of its having been fractured

When the ends of the bones partially overlap (Fig. 13 4 (2)), the amount of ensheathing callus is considerably increased and fills up all the spaces left

by the overlapping of the fragments. The projecting edges of bone become rounded off and the medullary cavities closed by plates or plugs. The main bond of union is the ensheathing mass, a considerable portion of which persists Some deformity is certain to remain and it is unusual for the medullary canal to be restored.

If the fractured ends overlap completely but remain in contact, the union is secured by a large mass of ensheathing callus (A) while the medullary cavity of each fragment is closed by a plate of internal callus (B)

If the fractured ends overlap and are kept from contact by the interposition of muscular tissue, union rarely takes place and an ununited fracture results (Fig. 13 5) The same occurs if the fragments are widely separated



FIG. 13 5 UNUNITED FRACTURE OF THE HUMERUS (PSEUDARTHROSIS.)

(distraction) as in the patella. In these cases, little change takes place in the bone at first beyond the closure of the medullary canal or of exposed cancellous spaces by granulation and then by fibrous tissue at a later date the bone ends are likely to undergo a certain degree of atrophy

Where *comminution* has occurred, the splintered fragments are matted together by an abundant cellular exudate, which is subsequently transformed into callus. Each of the fragments may become a centre of ossification and it is astonishing in some cases to note the rapidity with which extensive shattering is made good in the absence of infection or great displacement. Sometimes, however fragments of *compact* tissue may remain for a long time unchanged and with no sign of repair or may even constitute a cause of non union by being wedged between two fragments and keeping them apart.

The removal of the clot and the formation of the cellular exudate usually takes about a week or ten days. New bone formation starts about the end of the first week. By the second or third week, according to the size and vascularity of the bone and the recuperative power of the individual, the fracture will be less mobile, but of course cannot bear any serious strain. In the leg it is often eight or ten weeks before the patient can bear any weight upon it, and three to six months must usually elapse before a patient should be allowed to walk on a fractured thigh.

The soft tissues around, such as muscles and tendons, are repaired in the usual way, but owing to their laceration and infiltration with blood the muscles may become the seat of marked fibrous changes interfering with their contractile power, or may be fixed more or less firmly to the bony surface over which they ought to play smoothly, or may be matted together and lose to some extent their power of independent movement. Tendons often become adherent to their sheaths, or may be embedded in a mass of cicatricial tissue, hence the mobility of distal parts may be impaired in spite of the union of a fracture in good position. Neighbouring joints may become stiff as a result of periarticular infiltration, resulting in contraction of ligaments. Nerves and vessels may be torn by the displacement of the fragments, or compressed in cicatricial tissue or callus, hence the functional result after union of the fracture may be very disappointing.

Treatment of Fractures

Treatment may be considered under four headings:

(1) The treatment of shock and restoration of blood volume. This is only necessary in the more severe fractures of the large bones. First aid treatment, however, may be of very great importance.

(2) The correction of the deformity. This is also called "reduction" of the fracture or "setting" by the lay public.

(3) Immobilization of the fracture until union is complete.

(4) Restoration of function in the limb. This means the restoration of muscle tone, joint mobility and a normal circulation, both arterial and venous.

First Aid. In moving the patient from the spot where the accident happened it is necessary to secure the limb temporarily in as good a position as possible; splints have often to be improvised from sticks, umbrellas or even rolled up newspapers. In a railway accident the splintered débris of the carriages may be employed for this purpose and the upholstery of the seats as padding. A broken leg may be firmly tied to the other limb, which is thus converted into a temporary splint.

Reduction. The restoration of the bone to correct alignment requires a careful study of each lesion and the effect produced on the position of the fragments by the muscles of the part. The deformity, as already stated, is due to three main factors: the causative violence, the action of gravity and the pull of muscles. The chief methods employed to overcome these are extension of the limb by traction, relaxation of the affected muscles by anæsthesia and manipulation to place the fragments in apposition; the effect of gravity is overcome by supporting the limb. Often it is possible by flexion of a neighbouring joint to relax muscular tension and the fragments then fall into position almost without manipulation; in more troublesome cases longitudinal traction upon the distal end of a limb, with the joint

above the fracture fully flexed will permit of suitable coaptation of the fragments. One cannot insist on this too strongly in reference to fractures below the knee flexion of the knee relaxes the gastrocnemius and with it the tendo Achillis, so that it is often easy to reduce a fracture with a bent knee when traction with the limb straight has completely failed Care must also be taken to ensure that no abnormal rotation is present to this end the sound limb must be uncovered for purposes of comparison

As the manipulation is always painful and may elicit muscular spasm, it is necessary to administer an anæsthetic and radiographic control should always be available No undue delay should occur in undertaking the reduction of a fracture, as stiffness and infiltration soon follow and make the operation more difficult, but it is always desirable to delay it for a few hours, in order to treat shock or to prepare the patient for an anæsthetic.

The recognition for the need of continuous traction in the treatment of certain fractures of the shafts of the long bones makes it necessary to draw special attention to the principles underlying this procedure and the means available for securing their correct application

Sufficient force must be employed to counteract muscular contraction and spasm which are the chief elements in maintaining the deformity The deformity must be overcome by manual traction while the patient is relaxed under the anæsthetic. Continuous weight extension is then applied, to counteract muscle spasm rather than to reduce deformity In the thigh of a muscular adult a weight of from 10 to 15 lb (5 to 8 kg.) acting freely should be sufficient.

Since the object of the extension is to stretch the muscles which control the fragments, it is most important to secure a sufficient grasp of these structures. The femur for example, is surrounded by muscles, all of which, whether extensors, flexors, or adductors, are assisting in pulling up the lower fragment. The whole muscular envelope needs to be stretched, and if this is effectively performed the bone ends are much more likely to become satisfactorily approximated It is insufficient therefore, to apply the adhesive plaster merely up to the line of fracture the whole muscular envelope up to the next joint should be included *Skeletal traction* is usually employed in preference to strapping

As many joints as possible should be left free for movements. In the case of the femur only the knee joint need be immobilized until clinical union is obtained The hip ankle and foot are exercised freely from the start.

It is essential that *the limb should be slung clear* of the bed, so that the traction may exercise its full power without frictional resistance. Long rigid splints must also be excluded if extension is to be effective. Short splints guarding the fragments of the bone and helping to keep them in position may be of use, but must not extend beyond the neighbouring joints Skeleton splints of the Thomas or Hodgen type avoid these difficulties.

Effective *counter-extension* must always be provided and in the lower extremity the weight of the body is sufficient if the lower end of the bed is adequately raised.

It is essential to *control treatment* of certain fractures, by *radiography* of the limb at intervals to make certain that no slipping of the fragments has occurred and this is most important during the early stages, as it is easy to correct mistakes whilst the union is still plastic (*e g* fractures of the femoral shaft) *In cases where, in spite of suitable extension combined with relaxation*

of muscles and manipulation it has been impossible to secure or maintain coaptation of the fragments, operative measures will have to be considered

Alignment The correction of angular deformity shortening and lateral displacement are of importance in this order of precedence The persistence of angulation in the lower limb leads to loss of function and over a long period to the development of osteoarthritis in neighbouring joints Angulation in the forearm bones may limit the movement of pronation and supination

Perfect anatomical position is not always essential for good function and while it is a desirable end result it is not always obtainable Nevertheless it should be the target in the treatment of fractures

Immobilization. This may be obtained by

(1) External fixation by splints, slings or other contrivances

(2) Internal fixation by plates screws or nails inserted at open operation.

Splints These are of two types (*a*) the skeleton type made of iron rod—Thomas s or Hodgen s, (*b*) moulded on to the limb For this purpose *Plaster of Paris* is by far the most useful and has superseded all types made of wood or leather The latter are only used for first aid purposes. Polythene and other plastic materials are sometimes employed

Technique of Plaster Application In recent fractures it is safer not to apply a skin-tight plaster cast, but a plaster slab may be applied to one aspect of the limb without padding. The width of the slab should be such that not more than half of the circumference of the limb is covered The slab is allowed to set and the position of the fracture checked by X ray If satisfactory the other half of the circumference is well padded with wool and then plaster bandage is applied in a circular manner to complete the cast. If much swelling is to be expected or when the patient has to travel without adequate supervision or under service conditions, it is wise to split the cast along its whole length Wool padding is essential, stockinette alone is insufficient.

To sum up—careful moulding over bony points is needed to prevent pressure sores. In recent fractures, do not apply skin-tight plaster casts, which completely encircle the limb, unless the patient can be kept under *constant supervision* and facilities are available for *instant* removal of the cast, should the blood supply become endangered It is wiser never to do so except in late cases where all danger of swelling has passed. When the cast has set the fingers or toes must be examined to test for the presence of the circulation.

Where prolonged traction of the limb has to be maintained *skeleton splints* of the type devised by Hodgen or Thomas are now generally used, suitably modified for arm and leg. The essential element of Thomas s splint (Fig. 13 6) is a well-padded ring above, through which the limb is passed, to

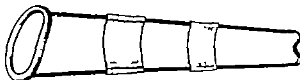


FIG. 13 6. THOMAS'S SPLINT AS EMPLOYED FOR FRACTURE OF THE THIGH.

exert pressure against the tuber ischii. The skin against which it rests must be shifted from time to time, so as to prevent the development of splint sores.

On either side a straight or bent iron bar passes down attached above to the ring and terminating below in a cross-piece, the level of which is well below the sole of the foot. Extension arrangements are fixed to the limb by glue or adhesive plaster or by some form of skeletal traction apparatus and attached to the cross-bar of the splint or connected with a weight hanging over a pulley Counter-extension for the leg is obtained by tilting up the lower end of the bed so as to utilize the patient's weight for this purpose. The limb itself is supported between the longitudinal bars as in a trough, by securing to them bands of flannel by means of safety-pins or spring paper clips. Deflection of one or both fragments to either side can be corrected by passing a broad flannel band round the limb and drawing it to the opposite bar to which it is secured or more certainly by the application of carefully padded hollow metal plates fixed to the sidebars and with screw adjustments sagging downwards of the fragments is corrected by tightening the bands forming the trough displacement forwards by passing a band above the limb and attaching it to either bar In this way slight modifications are easily made. Sometimes the additional incorporation of short splints in front or behind is of considerable importance in steadying the parts.

Of value in treating fractures of the lower end of the femur by skeletal traction is Braun's splint, because it readily enables movements of the knee joint to be carried out. It is also of value in treating fractures of the tibia.

Internal Fixation. This plan was first advocated and utilized by Lord Lister for such bones as the patella or olecranon but its adoption for the long bones was largely due to the teaching and example of Sir W Arbuthnot Lane.

The advantages secured by operative reduction and internal fixation of a fracture, must be weighed carefully against the disadvantages, before the decision to operate is made. The risks are those of the anæsthetic, the possibility of introducing sepsis and the further damage to soft tissues and the blood supply of the bone. Union of the fracture will be somewhat delayed when an operation is performed, but this disadvantage will be offset by the accuracy of reduction and fixation.

The general indications for operation upon fractures may be stated thus

(1) Where control by external splinting is not possible, *e g* fractures of the femoral neck.

(2) Avulsion fractures with wide separation of fragments, *e g* patella and olecranon.

(3) Fractures involving joints, *e g* condyles of humerus or femur and fracture dislocations of the ankle.

(4) Fractures of the shafts of long bones with interposition of soft tissue or where alignment is difficult to maintain, *e g* subtrochanteric fracture of femur

The *time for operation* must be carefully considered it may be wise to delay it for a few days, partly to allow the patient to recover from the shock of the accident, partly to permit of effective preparation of the limb. Any time during the first week will be satisfactory During the interval of waiting it is wise to apply effective weight extension so as to prevent any increase in the deformity and to reduce the amount of manipulation required at the operation. In the elderly patient who has sustained a fracture of the femoral neck it may be wise to regard the operation as an emergency and to perform it within a few hours. This will enable the patient to sit up in a chair

on the same day and will do much to limit the onset of pneumonia thrombosis, incontinence and mental decay

The operation itself must be conducted with the most minute care as to aseptic precautions. The skin must be previously shaved and cleansed All direct handling of the wound is to be avoided manipulations being carried out by means of instruments The long handled instruments devised by Lane are particularly suitable for this work The incision should be planned so as to give effective exposure to the site of fracture The surrounding skin should be protected by towels clipped on the wound margins The ends of the fragments are exposed cleared brought into correct position with as little manipulation as possible and held by suitable forceps, while their fixation is being accomplished After this has been done the displaced periosteum is, if possible drawn together so as to limit the field of activity of the osteoblasts and to prevent adhesions of the muscles to the bone muscles and deep fascia of the limb are carefully sutured as also the skin An external splint is often required

Bone Fixation. Various methods are available and it is not always easy to determine which to employ Much ingenuity has been exercised in the production of these.

Wire Fixation It may be sufficient to hold the fragments together by stainless steel wire of appropriate thickness, *e g* for the patella or olecranon or for some oblique fractures of long bones. For the latter it is desirable to drill the bone in two positions and introduce the wire as a mattress suture, in a very oblique fracture two such sutures are desirable instead of one. Care must always be taken to tighten the wires securely by twisting, but not to twist off the ends the knots must be bent over and beaten down, so as not to cause irritating projections.

Screw Fixation When the fracture extends through masses of cancellous tissue, *e.g* the condyles of the femur or has involved fragments covered with muscular origins, the complete displacement of which would be undesirable *e g* the condyles of the humerus, it is often possible to fix the fragment in position by screws, nails, or pegs of bone. It is usually desirable to introduce two of these to secure the fragment from rotation.

Plate Fixation. For fractures through the shafts of long bones, *Lane s plates* or some modification of them have been largely employed They consist of metal plates of stainless steel or vitallium alloy which can be bent by suitable wrenches to fit accurately to the contour of the bone They are supplied with a varying number of holes for screws, according to the type of fracture holes are drilled through these into the bone, so as to perforate both cortices. For a fractured tibial shaft at least four screws are required and for a femur six or eight.

Experience has, however shown that there are many objections to their employment as a routine method of treatment. (*a*) It is essential to secure a firm hold of each fragment by the use of a long plate this involves considerable stripping of periosteum thereby interfering with the nutrition of the bone. (*b*) Absolute fixity of the fragments without the possibility of the slighest movement does not conduce to rapid or effective union the best results are secured when it is possible for the ends to rub one against the other without displacement. Non-union in the ribs is unknown delayed or non-union after " plating " is not uncommon (*c*) The local effects of the screws on the bony tissue may cause rarefaction, so that the firm hold is

lost in a short time. This is specially so unless both screws and plate be of identical metals. Dissimilar metals result in the setting up of an electrolytic action The other cause for rarefaction and loosening of screws is sepsis. If splints or other retentive apparatus are removed too soon, so that powerful muscles can come into action, displacement and deformity may readily appear especially in the shaft of the femur (*d*) Infection of the wound is almost always associated with death of the portion of bone lying under the plate and may reach the medullary cavity through the screw holes. Delayed auto-infection may also occur arising in the small hæmatoma or from the damaged tissues around the plate. (*e*) Metallic plates or wires should not, in general, be used for an open fracture owing to the presence of sepsis, which must be assumed in every case.



FIG. 13 7 INTERNAL FIXATION BY MEANS OF A STAINLESS STEEL PLATE AND SCREWS.

Intramedullary Fixation. This means of fixation has been used for many years, the modern version being an intramedullary nail of stainless steel being in section C-shaped or V-shaped This is known as the *Küntscher nail* and is most suitably used in fractures of the femoral shaft.

External Clamps This form of fixation whereby the clamps are connected with long removable screws has been advocated by some authors, *e.g.* Hey Groves and Roger Anderson, but their employment is not generally recommended or feasible.

In conclusion it should be noted that internal fixation is usually unnecessary in the fractures of children it is sufficient to expose the fracture and having aligned the fragments, to close the wound, relying upon external splinting for immobilization.

Restoration of Function. Certain principles must be observed in order to prevent muscle wasting and joint stiffness.

(1) The fracture must be *immobilized* but unnecessary splinting of joints

must be avoided All joints must be moved several times daily unless this movement jeopardizes the immobilization of the fracture

(2) All muscle groups must be *exercised* if possible by active voluntary contractions, or if not, by electrical stimulation. This prevents wasting and loss of tone and improves the blood supply to the bone so that the fracture unites more quickly The patient should be told to perform active contractions for a definite period each hour of the day

(3) *Psychological aspects* must not be forgotten Congenial occupation of the mind is an important part of fracture treatment *Occupational therapy* offers mental occupation and physical exercise which in many instances can be adapted to the improvement of muscle tone and the prevention of joint stiffness, at an early stage in the treatment.

(4) The role of the *physiotherapist* in the early stages is largely one of encouragement and coercion. She must see that the patient carries out his exercises voluntarily and assist these movements where necessary She must not forget that the sound limb also needs exercise and that deep breathing is important in the prevention of pulmonary complications. In the later stages of treatment, massage and heat may play a supplementary part but it is important to remember that the need for these varies inversely with the efficiency of active rehabilitation in the early stages.

Ambulatory Treatment. Certain fractures in the lower limb *e g* tibia and ankle, may be treated by fixation in a plaster of Paris splint in which the patient is allowed to walk, after allowing a few days for the preliminary swelling to subside. The active muscular contractions thus obtained together with the slight movement of the fractured surfaces, are conducive to rapid consolidation and minimize the need for subsequent physiotherapy



FIG 13 8 WALKING PLASTER.

It is advisable to protect the plaster from direct contact with the ground either by a metal stirrup of the Böhler pattern or by a wooden rocker (Fig. 13 8)

Œdema When a lower limb plaster is removed the limb will swell owing to loss of support to the soft tissues and this swelling will continue until vasomotor tone is restored This may take some weeks During this time a firm supporting elastic bandage must be worn.

Complications of Fractures

Involvement of a Joint. When the fracture extends through the articular cartilage, the joint becomes distended with blood and synovial fluid, but the lymph, which develops into scar tissue *Aspiration* of the joint should b undertaken if the distension is excessive. If the fragments are in perfe apposition, no permanent harm need result. If however the apposition imperfect, adhesions of a more serious type develop and considerable limita tion of movement may follow It is thus comprehensible that one of the chief indications for the operative treatment of fractures is when they involve joints. In elderly people injuries of this type may result in traumatic arthritis, causing pain and limitation of movement.

Dislocation. The violence that causes a fracture may at the same time produce a dislocation in a neighbouring joint, particularly in connection with the elbow and shoulder Treatment should always be undertaken as soon as possible. Should the fracture involve or be close to the articular end of the bone, an attempt should be made to reduce the deformity by manipulation under an anæsthetic failing this, or if the deformity recurs, open operation should be undertaken In most cases the dislocation can be reduced after removing the extravasated blood and the fracture fixed but sometimes, when the displaced articular fragment is small, it is wiser to excise it.

When the fracture is further away from the joint, it is sometimes possible to control the fragments by splints, and to reduce the dislocation under an anæsthetic. Should this fail, the surgeon may either fix the fracture by operation and repeat the attempt to reduce the dislocation, or he may open the joint and perform an open reduction.

Arterial Injury An artery may be compressed, contused punctured or ruptured, giving rise to thrombosis, aneurysm or hæmorrhage. In the former case dry gangrene may result in the latter moist gangrene may be produced by the pressure of the extravasated blood on the veins. This is most frequently observed in fractures of the lower end of the femur where the femoral or popliteal artery may be involved.

Treatment Here it need only be mentioned that in the case of a ruptured artery operation should, if possible involve not only the removal of the blood clot and the securing of the artery but also the fixation of the fracture (see Volkmann's ischæmia)

Venous Injury Laceration of veins results in extravasation of blood which is not so extensive as when an artery is wounded, since thrombosis occurs more easily the distal part of the limb may become congested and œdematous, and this may require for its removal firm bandaging, massage and exercises Pulmonary embolus is an occasional sequel of venous thrombosis.

Nerve Injury The nerves of a limb may be injured at two different periods. (*a*) Immediate injury is due to bruising or rupture (*b*) Secondary

symptoms result from inclusion and compression of the nerve in the callus or from splint pressure

Treatment For a time this is expectant even when the paralysis is immediate, since total rupture of a nerve is rare and restoration of function the rule rather than the exception When however the symptoms persist, the parts must be explored the nerve freed from adhesions, or exuberant callus removed and such measures taken as will best secure the nerve from further compression

Complications Arising during Treatment. (1) If an elderly patient is kept in bed for any length of time in the recumbent posture, *hypostatic pneumonia* is likely to ensue It occurs most commonly in elderly patients after intra capsular fractures of the femoral neck unless these are fixed by nailing and the patient is out of bed within a few days

(2) *Bedsores* are very liable to supervene in old people with fractures which need treatment in the recumbent posture

(3) *Crutch palsy* is the result of compression of the radial nerve between the head of the humerus and the pad of a crutch. Other nerves may be affected It can usually be prevented by the use of spring padded crutches with cross-pieces for the hand so as to allow the patient partially to relieve the axillary pressure by supporting the weight of the body by means of the arms, or by employment of the modern stick-crutch When it has occurred, the use of crutches must be discontinued and the paralysed muscles treated.

(4) *Volkmann's contracture* (p 173) sometimes develops in cases of fracture of the forearm or elbow in children

(5) Another muscular complication is *myositis ossificans* (p 177).

(6) *Gangrene* may arise from fractures in a variety of ways (*a*) From immediate effects of the injury either by its direct action on the tissues, or by causing arterial thrombosis in a limb with atheromatous vessels, or from rupture of the artery with consequent venous thrombosis, owing to the pressure of the extravasation, (*b*) by the supervention of gas gangrene in an open fracture, (*c*) from errors in the course of treatment, as by bandaging the limb too tightly so as to constrict the vessels by the bandage becoming unduly tight, owing to the subsequent swelling of the limb by flexing a joint after bandaging it the bandage cutting into the soft tissues or by the localized pressure of a splint which has been insufficiently padded. *Moist* gangrene is the type always encountered except when the limb has been previously drained of its fluid by an atheromatous condition of its vessels.

(7) *Splint sores* constitute a form of localized gangrene due to the pressure of a badly fitting or imperfectly padded splint, or possibly to bandaging on too tightly a splint which otherwise would be satisfactory The commonest situation is over the heel when the limb has been kept for a time on a back splint with a foot piece It is also sometimes seen over the bony prominences of the malleoli or shin, or over the neck of the fibula resulting in a peroneal palsy

Open or Compound Fractures

An open fracture is one in which there is a communication between an external wound and the fracture site. It is caused by direct or indirect violence, the solution of continuity of the skin being produced in the former from without, and in the latter by the penetration of a bony fragment from within. It is also sometimes secondary to treatment, the skin over the

fracture sloughing as a result of pressure or irritation. The bone may be but little displaced, or may protrude through a small opening in the skin or the bone may be crushed and comminuted and a large fleshy wound associated with it. In some of the injuries produced by railway or machine accidents, gunshot wounds, or motor-cars, the skin and muscles are violently torn across, and the underlying bone pulped, while road dust, grease and dirt of many types are ground into the tissues.

Infection The chief peculiarities of open fractures are due to the existence of the external wound which permits of the entrance of bacteria into the depths of the limb The infection is likely to be mixed and may include anaerobic organisms such as those of tetanus and gas gangrene. Local osteomyelitis at the fracture site may be responsible for delay in union, or non union and be accompanied by blood stream infection or septicæmia. Amputation may become necessary

Hæmorrhage This occurs to a variable degree according to the size of the vessels involved, but as the lesion is not usually produced by cutting, the vessels may become sealed by natural processes Secondary hemorrhage is not uncommon in septic cases, as the result of a periarteritis, particularly if a sharp fragment lies in close contiguity to a large vessel.

Soft tissue Injury Muscle bellies often protrude through the opening in the deep fascia by which they suffer constriction and present as an œdematous mass which may become gangrenous drainage of the deeper parts of the wound is thereby hindered Anaerobic invasion may lead to localized gas gangrene.

Tendon sheaths if opened provide a favourable nidus for the development of organisms and the suppuration may track up or down for a considerable distance The tendons themselves slough or contract dense adhesions to their sheaths.

Bone Effects These vary If the shaft is broken cleanly an acute osteomyelitis may follow if drainage is defective but if there is a free exit to discharges, all that may result is a limited necrosis of the compact tissue of the end of one or both fragments. If the fracture involves cancellous tissue an acute infective osteitis follows, leading to carionecrosis, and possibly by direct extension involving neighbouring joints and bones. The existence of *fissures* extending from the main fracture does not necessarily involve a spread of suppuration along them unless tension, from want of drainage, is present. Infection almost invariably leads to death of all totally detached fragments, but those which retain their periosteal connection will probably live and be useful in the reparative process if satisfactory drainage is established.

Joint Injury Neighbouring joints may become infected at the time of the original injury or subsequently by secondary extension through living bone or along fissures. In old-standing cases with necrosis and chronic sepsis, joints may become stiff by prolonged immobilization, and then forcible attempts to break down adhesions and free the joint may result in lighting up an acute suppurative arthritis.

Nerve Injury Nerves may be injured at the time of the accident, or damaged at a later date by inclusion in the callus or in cicatricial tissue. The phenomena are identical with those following a closed fracture but unfortunately nothing can be done to repair them until the sepsis has been overcome.

It will be clear from the above brief generalization that while open fractures may be followed by good results if treated early and effectively delay or defective treatment may involve the patient in the gravest dangers of an infective nature (pyæmia septicæmia etc.) or may lead to a most wearisome and prolonged convalescence Life and limb alike are threatened even if both are saved, great and crippling disability may follow

Method of Repair An open fracture heals in much the same way as the closed variety but necessarily repair is largely influenced by the presence or absence of complications.

If the wound can be cleaned within six to eight hours, it may be closed at once or by delayed primary suture and the fracture treated in the same way as one with no skin involvement. The repair is then identical in the two types. The same occurs if infection involves merely the soft tissues After eight hours, however the wound will almost certainly become infected and some necrosis of bone with delay in healing is likely

If the fracture is *a clean break through the shaft* and the necrosis limited to a small section of the compact tissue on one or both fragments, the dead bone is separated by a process of rarefying osteitis in the neighbouring compact tissue the marrow cavity is shut off by a medullary plug of soft bone the superficial layer of which is converted into granulation tissue While this is occurring, new bone is being formed from the osteoblasts adherent to the neighbouring periosteum and this may suffice to bridge the gap between the fragments and determine their union. The bond of union thus formed constitutes an involucrum to the dead bone, which lies within and is gradually separated If the sequestrum is small, it may find its own way to the surface but usually the external wound has narrowed to such an extent during the interval as to prevent its escape and operation must be undertaken When once the sequestrum is removed a clean granulating cavity persists which should heal

Sometimes, however the presence of the sequestrum maintains so much irritation that reparative changes cannot occur so long as suppuration persists, and the fracture remains ununited removal of the sequestrum may then determine union.

In *cancellous bone* a septic fracture will be followed by a spreading osteitis until efficient drainage is provided, then the destructive process comes to an end and repair follows.

Comminution of compact bone is a serious complication in an infected open fracture. Fragments totally detached die and, unless they are removed cause persistent suppuration. Fragments retaining their periosteal connections live and undergo active changes, either destructive or reparative, according to the degree of infection present. Where drainage is free, the fragments are welded together by granulations around the central cavity of the fracture, and these granulations are converted into new bone

In cancellous tissue a similar process occurs when the parts are freely opened up, drained and all loose fragments removed Too conservative a policy results in the retention of both dead and living fragments, between which pus burrows, coming to the surface in various directions, so that the whole area of the injury may be riddled with sinuses. Some degree of reparative activity occurs, and in time the site of the injury may be occupied by a swelling, which consists of a curious mixture of dead and living bone, between the constituent elements of which lies a mass of œdematous tissue,

partly granulation, partly cicatricial sinuses track through this mass and the patient may become gravely ill and anæmic from toxic absorption. No repair can be expected so long as this mass persists, and cure can only be established by clearing out the whole infected area.

Treatment of Open Fractures. This has two objectives, (*a*) to prevent the development of infection or to limit its spread, and (*b*) to fix the limb so that repair of the bone may occur with as little deformity as possible.

The prevention of infection is really a question of time If the patient is seen early much can be done if there is delay sterilization of the wound is almost impossible The rules already given must be followed out with the greatest care Penicillin in full doses is given at the earliest opportunity The skin of the limb is shaved and cleansed the margins of the wound are excised the cavity of the wound is laid open by suitable incisions, so that the interior may be thoroughly explored Damaged and hopelessly torn tissues are cut away so as to leave a free approach to the site of the fracture, which is dealt with appropriately If the surgeon is satisfied and the operation has been done within *six hours* of wounding, he may close the wound. If he is doubtful as to the result of his efforts, or if after six hours of wounding, the wound should be left open and a petroleum jelly gauze pack inserted lightly A secondary suture may be possible if the wound is clean in a few days A counter-opening may be necessary but *in no circumstances must a drainage-tube be carried across the site of the fracture so as to lie between the fragments* necrosis is certain to follow such a procedure.

The limb is preferably encased in a plaster cast to provide immobility and to prevent access of infection. This is the basis of the method introduced by Winnett Orr of America.

The treatment of the bone itself varies with the circumstances When merely a sharp end of one of the fragments protrudes through a small opening in the skin, the latter is first thoroughly cleansed and then after the margins have been excised and the wound if need be, enlarged, reduction is effected, and the wound closed. In clean breaks without protrusion, the fractured ends are apposed in the usual way and the limb placed on a suitable splint Skeleton splints of the Thomas type are of the greatest value in open fractures, in that the limb need not be disturbed when the wound is dressed the flannel bands which constitute the trough in which the limb lies must be so arranged that, by the removal of one or more, easy access to the wound is secured.

When suppuration persists, necrosis has probably occurred, and radiography is useful in determining when the sequestrum is free. It must be remembered, however that sequestra seldom take more than two or three months to separate, and often less. As soon as separation is effected, operation to remove the sequestrum must be undertaken delay involves thickening and condensation of the involucrum, with subsequent trouble in determining closure of the sequestral cavity

All secondary operations required for non-union or nerve lesions must be postponed till the wound has been satisfactorily healed for some time.

The question of *amputation* must, on occasion, be considered, both immediately or as a secondary procedure, and is discussed in Chapter 12. Amputation must not be decided on without the most careful consideration at the same time it is useless to retain that which may become a source of

serious danger or even if saved remain an encumbrance As a secondary operation, amputation is needed mainly for severe recurrent secondary hæmorrhage, grave infection of a neighbouring joint or of surrounding bones (as in the tarsus) or chronic anæmia and toxæmia due to persisting and long-continued suppuration Gangrene from whatever cause may also require amputation but not necessarily at the site of fracture

Chronic Necrosis This in the past has been unfortunately a sequel seen only too commonly after open fractures due to gunshot wounds. The unfortunate patient retains one or more suppurating sinuses, from which perhaps small spicules of bone are discharged this may be followed by healing which persists for a time and then possibly as the result of some slight injury the wound flares up the limb swells and the cicatrix gives way permitting exit to a quantity of pus. A probe is passed and finds its way into a bony cavity along a passage which may be straight or tortuous bare bone is touched and the doctor not unfrequently decides to "scrape it out." This is done more or less thoroughly probably through a small incision fresh bony tissue is laid bare and infected fresh necrosis follows and the whole trouble is repeated This goes on time after time, and operation follows operation, sometimes for years. At the end of fifteen to twenty operations the patient is in a rather worse condition than previously and frequently requests removal of his limb

The local conditions present in these cases vary considerably but as a rule there is a sequestrum of greater or less size lying in a cavity which is almost surrounded by bone which becomes increasingly dense and non vascular as the months pass, until sometimes it is as hard as ivory It is obvious that reparative changes can occur only very slowly in such tissue, and that scraping cannot be expected to bring about healthy activity The sinuses which reach this cavity are often narrow and may be badly placed for drainage or dressing the constant passage of discharges and the daily introduction of gauze packing (often too tightly) suffice to determine a spreading sclerosis in the surrounding soft tissues which will impair subsequent usefulness. Even if the sequestrum is taken away successfully without waking up fresh trouble, healing does not always occur since the bone may be tunnelled, and the sides of a bony tunnel necessarily cannot fall together A rare complication of prolonged sepsis is the development of malignant disease in the sinus.

Treatment is often very difficult and is usually irksome both to doctor and patient. The actual operative procedure must be governed by the following considerations (*a*) A stereoscopic skiagram of the limb must be secured in order to enable the surgeon to visualize clearly the conditions he is called on to treat. (*b*) The trouble in the bone must be approached by a route which enables him effectively to deal with it if the existent sinuses happen to fall into the line of his incision, well and good if not, the sinuses will probably close quickly after the essential cause of the trouble has been dealt with. (*c*) The incisions must be sufficiently long to enable *all* the trouble in the bone to be reached The ideal condition to be left after operation is a wide shallow gutter or crater with no overhanging bony lips. This necessarily involves the cutting away of a good deal of bone in many cases, for which suitable chisels and gouges are required but the dense bone often found is very unfavourable for reparative purposes. Tunnels in the bone are treated, if practicable, by removing entirely one side of the tunnel

so as to convert it into a gutter into which the surrounding soft tissues may fall.

The cavity thus formed is carefully dried, hot saline solution being employed as a hæmostatic a light Vaseline-Gauze pack is inserted. If there is little discharge, frequent dressings are quite unnecessary and indeed harmful probably it suffices to change the gauze once in ten days. Occasionally the surgeon may feel justified in closing the cavity entirely but this is not often possible

Ununited Fractures

There are three varieties of ununited fracture (*a*) *Absolute non-union*, when no attempt at repair is made, may result from fractures due to the presence of some local disease which has led to wide destruction of bony tissue, such as sarcoma, or from the resection of extensive areas of bone for sarcoma or gunshot injuries. (*b*) *Fibrous union* consists in the development of a more or less firm mass of connective tissue as the bond of union between the ends of the bones, which are either rounded off or closed by a thin plate of bone or cartilage. The bone ends are often sclerosed but sometimes atrophied and pointed (*c*) A *false joint* or *pseudarthrosis*, is a condition in which the ends of the fragments are covered either by bone or cartilage and more or less altered in shape, so as to form a shallow ball-and-socket joint, the capsule being represented by the surrounding fibrous tissue, and the synovial cavity by the formation of an adventitious bursa.

The most common situations for ununited fractures are projecting processes of bone to which powerful muscles are attached, such as the patella, olecranon, or the shafts of the humerus or lower third of the tibia. The latter is a common site as the vascularity here is poor

Causes (*a*) Want of apposition of the bony ends, owing to extensive resection, or to muscular action, *e g* in the patella, when the two fragments are widely separated, (*b*) the interposition of muscular or aponeurotic tissue, or detached fragments of compact bone, (*c*) failure of efficient reduction and maintenance of the reduction (in this respect non union associated with *too heavy traction* whereby the fractured ends are artificially separated should be noted), removal of excess weight may not allow the bones to make contact owing to interposition of soft tissue, (*d*) defective blood-supply to one or both fragments as by injury to the nutrient artery or as in transcervical fracture of the neck of the femur where the only source of supply to the upper fragment is a small twig derived from the obturator artery running along the ligamentum teres, (*e*) local affections of the bone, such as suppuration with necrosis in compound fractures, malignant tumours, or the undue pressure of pads upon newly-formed callus, (*f*) general bone diseases, such as Paget's disease, or osteomalacia, and (*g*) general constitutional weakness or debility

Physical Signs. Evidence of malunion is usually obvious, mobility between the fragments being easily obtained in some directions, though perhaps not in all crepitus is absent. It is perfectly possible, however for a person with good muscular development to have an ununited fracture with but little functional disability the condition may be obvious when the muscles are relaxed, but disappears when the muscles contract. In doubtful cases radiography will help in diagnosis.

Prognosis This is fairly good if suitable treatment is adopted, and the

local or general conditions do not prohibit reunion In particular emphasis must be laid upon the necessity for patience in the non-union associated with infected open fractures. Until all necrosed tissue has been removed and the infection overcome reparative processes are often slow in being established If the parts be fixed and the vascularity of the limb increased by static contraction of muscles, and if the general health be improved repair without operation can often be established in time *Bone grafting* is not always successful because the graft may be absorbed or latent infection lighted up In such cases amputation may be the final solution

Treatment (1) If the fracture is in good position, but the bone ends are sclerosed there is no absolute bar to union The tibia is a common site for this type of delayed union Immobilization in an above-knee walking plaster may sometimes be successful, but it is usually better after a few months, to waste no further time but proceed to operative treatment.

(2) *Beck's drilling* may be tried This consists of making a number of radiating drill tracks across the sclerosed bone of the fracture line. The drill can be introduced through a small skin incision placed just above the fracture line and another one just below it, so that the two sets of tracks cross A walking plaster cast is then applied.

(3) *Autogenous bone grafting* is the method of choice. The fracture site is exposed The periosteum is opened and all further manœuvres performed inside the periosteal sleeve. It is essential to remove or break up as much of the sclerosed bone as possible The fracture is aligned and the bones united by an on-lay bone graft. This is fixed firmly in position by stainless steel or vitallium screws. The graft may be supplemented by cancellous chip grafts taken from the iliac crest The operation of bone grafting can

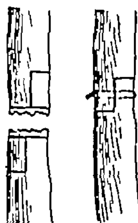


FIG. 13 9 STEP OPERATION WITH UNION EFFECTED BY A MATTRESS SUTURE OF WIRE. THIS OPERATION MAY BE COMBINED WITH AN ON-LAY GRAFT

be combined with a "step" cut in the bone ends (Fig. 13 9) but it is probably better to avoid this owing to the shortening which it produces.

(4) When an actual gap has to be bridged, the above type of operation combined with cancellous grafts is often successful, or an intramedullary graft can be used. A plaster cast must be retained until there is radiological evidence of consolidation. Provided that the hazard of sepsis can be avoided, these types of bone grafting operations are usually successful.

Malunion. This results either from imperfect reduction or subsequent displacement. The difficulty of managing serious open fractures explains the frequency with which malunion is seen after gunshot wounds. Various kinds of deformity may result and, if these are serious, means must be taken to remedy matters. If observed early when the callus is soft, angulation may be corrected by manipulation under an anæsthetic—if necessary refracturing the bone. Shortening or gross deformity must be corrected by open operation and the fragments fixed by some form of internal fixation. It is essential to remember that in the case of fractures which have been *infected*, there is

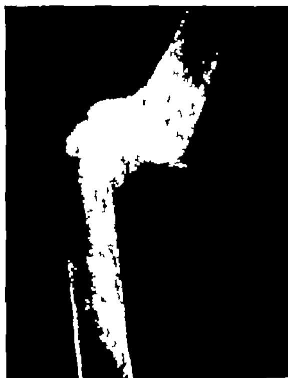


FIG 13 10. MALUNION IN A FRACTURE OF THE FEMORAL SHAFT

always the danger of lighting up further inflammation. Before operating, the surgeon must be certain (*a*) that there are no clinical signs of activity. It is wise to wait at least six months after all signs of serious inflammation have ceased and to operate under an "umbrella" of penicillin or other suitable antibiotic. Where doubt exists, a useful precaution is to manipulate the fracture under an anæsthetic. Infection may be lighted up, thus saving the patient from the much more serious consequences of an infected bone graft. (*b*) The skin over the fracture site must be in good condition and not adherent to bone. If the skin is unhealthy it must be replaced by full thickness grafting before the bone is dealt with.

Bone-grafting

Bone-grafting is an operation which is required for many ununited fractures, especially where there has been great loss of tissue, as also for reparative purposes where much bone has been removed with tumours or cysts. It is also employed for purposes of fixation of joints or of the spine.

Grafts may be *autogenous* (from the patient) *homogenous* (from another patient) or *heterogenous* (from an animal) In the last case the graft must be boiled to ensure sterility

There is evidence that a living autogenous graft is more effective than dead bone which has been boiled Exactly how much of a living graft remains alive in the tissues of the host is doubtful Probably most of it is replaced by a process of "creeping substitution by the cells of the host If this is true, the majority of a cortical graft acts merely as a framework upon which the host cells can build

Grafts of cancellous bone being small and of open texture are more likely to live. They are useful for packing around fractures or for filling bone cavities. When rigid fixation is required cortical bone must be used Sometimes a graft is absorbed completely after an apparently successful operation, and non union follows The factors which govern the success or failure of a bone graft are not fully understood

Many methods of grafting have been employed from time to time varying with the different ideas as to the destiny and usefulness of grafts, and with the manipulative dexterity and mechanical appliances at the disposal of the particular surgeon.

(1) It is possible to utilize fragments of living bone either loosely powdered in the cavity to be filled or firmly packed in. These may easily be procured from the iliac crest (cancellous bone) or the subperiosteal surface of the tibia (cortical bone). It is probably best to pack the cavity firmly and close it entirely If the grafts survive it is on account of the blood-plasma permeating through the cavity until the time arrives when the whole mass is vascularized and organized An ununited fracture may be treated in this way by freeing the ends and making a fresh section of them to expose healthy bone tissue. The fracture is then fixed e g by a plate or better by a bone onlay graft, and the interval between the fragments packed firmly with bone chips.

(2) In some situations all that is required is a thin lamella of bony tissue, e g in cranioplasty or in some ununited fractures of the lower jaw A suitable shaped flap is marked out on the front of the tibia or crest of the ilium and the superficial layer of bone, together with the periosteum is chiselled up and transplanted In some fractures of the jaw a thin graft such as that described may be rolled up like a cigarette and fixed between the bone ends.

(3) In other places a more massive graft is desirable and for this purpose complete sections of bones, e g of the fibula, or rib are employed

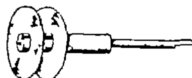


FIG 13 11 DOUBLE CIRCULAR SAW FOR BONE-GRAFTING (ALBEE). The distance between the two saws is easily regulated.

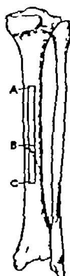
The introduction by Albee of the double circular saw (Fig. 13 11) driven by an electric motor has revolutionized this procedure and placed in the hands of surgeons the means of rapidly cutting grafts, which are well adapted

for the part they have to play The front of the tibia is the favourite site from which to obtain such grafts for work on the long bones.

It is hardly necessary to point out that for success the following essentials must be secured (*a*) *Absolute asepsis* This excludes early operation on compound fractures, however desirable it may appear from the functional standpoint. Healing must have been secured for some time before bone grafting is considered (*b*) *Hæmostasis* is necessary in order that the graft may unite rapidly with the surrounding tissues and thus its vascular supply be ensured the presence of a hæmatoma may jeopardize its vitality (*c*) *Effective fixation* is most desirable, but if this can be secured without the use of nails, screws, or wires, so much the better these all have a tendency to hinder reparative activity in their immediate neighbourhood Autogenous *bone nails or pegs are very useful and may be cut by the shaper provided* with the Albee saw outfit. (*d*) Complete rest must be provided after the operation, so as to permit of effective healing between the bone and the graft too early mobilization might break up this bond of union. (*e*) On the other hand, as soon as union is effective active use of the limb is desirable in order to stimulate its growth, the amount and direction of which reacts to the strain and stress placed upon the part. In other words, growth and structure depend on function.

There are three different methods of bone graft suitable for lesions of the long bones.

The Sliding Inlay Graft. This is a useful method for dealing with fractures which are difficult to retain in position, or for certain ununited fractures. It consists in cutting a long narrow graft extending over both fragments



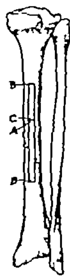


FIG. 13 12. SLIDING INLAY BONE GRAFT



FIG. 13 13 BONE GRAFTING BY A "STEPPED" LATERAL GRAFT

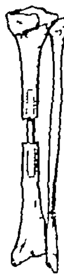


FIG. 13 14. BONE GRAFTING BY AN INTRAMEDULLARY PEG.

(AB and BC) in such a manner that the portion derived from one fragment is double the length of that from the other They are detached from their deep connections, and the longer (AB) is slid down so as to lie across the line of fracture the shorter (BC) is transferred to fill up the gap left by

the displacement of AB If the grafts go down to the medullary tissue they fit accurately and no fixation wires or screws are necessary the periosteum is first stripped back and replaced at the end of the operation

The Lateral Onlay Graft This is employed more frequently where there is actual loss of substance The parts are laid open the ends of the

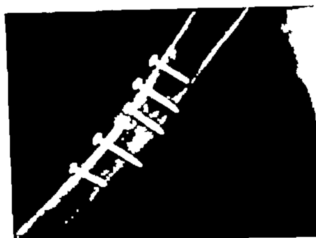


FIG. 13 15 LATERAL ONLAY BONE GRAFT HELD IN PLACE BY STAINLESS STEEL SCREWS.

bone freed and suitably "stepped" so as to receive the graft cut from the tibia. It is laid in position and fixed by wires or bone pegs or screws and the gap packed with iliac bone chips. A similar plan may be adopted for ununited fractures with no great loss of substance (Figs. 13 13 and 13 15)

The Intramedullary Peg. This gives fairly accurate fixation but as already pointed out it is not an altogether desirable method of procedure There is also a considerable liability to fracture of the graft if too early exposed to strain (Fig. 13 14)

INJURIES OF JOINTS

Sprains or Strains. These result from sudden violence applied to a joint either directly or indirectly and consist in tearing or stretching of ligaments or tendinous insertions of muscles. In many instances the synovial membrane is also involved. The accident itself is very painful and is followed by heat and swelling of the joint due to a hæmorrhagic effusion, which with care and rest disappears in a few days. With suitable after-treatment the joint recovers perfectly but in the absence of such treatment recurring attacks of pain and persistent weakness are likely to develop.

Careful palpation to discover the most tender spot indicates the situation of the lesion, which may be at the insertion of the ligament, or at any part of its course. Treatment consists in putting the part to rest and supporting it firmly by a bandage or strapping so as to limit effusion and to bring the segments of the divided structure into close apposition In the more severe cases a splint should be applied. The torn ligament must be protected from strain for a month.

Thus, in a sprained ankle, the lesion commonly involves one of the fasciculi of the lateral ligament. To bring the damaged structures into apposition,

the foot is everted and bandages or strapping must be applied so as to maintain this position. Hence these must pass across the sole of the foot from within outwards and upwards. When the patient begins to get about once again, this position must still be kept up by the use of a shoe, the heels and sole of which are thickened slightly on the outer side. Similarly if the medial ligament is damaged, the foot must be kept in the varus position and the sole and heel of the shoe thickened by wedges placed on the inner side.

A sprain of the medial ligament of the knee causes tenderness over the joint line or over its attachment to the tibia (Fig. 13 16) and pain is elicited by abduction of the leg. The synovial effusion is treated in the usual way by rest on a splint, when this has disappeared the joint must be strapped or firmly bandaged and the weight diverted to the outer side of the limb by thickening the inner aspect of the sole and heel of the shoe. The maintenance of good muscle tone by regular exercises is essential.

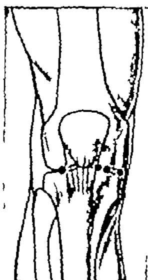


FIG 13 16. POINTS OF TENDERNESS ON THE JOINT LINE IN LESIONS OF THE LATERAL AND MEDIAL MENISCI.

Penetrating Wounds of Joints. These are often accompanied by an escape of synovial fluid which is recognized as a glairy oily substance, floating on the surface of the blood. If however the aperture is small this may not occur. It is always followed by a certain amount of reaction, the character of which depends on whether or not the joint is infected. If no infection has taken place, a simple synovitis ensues. If however infection has occurred suppurative synovitis often supervenes, usually leading to acute arthritis and disorganization of the joint.

Treatment. If the wound is small and there is reason to believe that infection has not occurred, penicillin should be given, the skin should be thoroughly cleansed and a dressing applied, together with a suitable splint to keep the limb at rest. A careful watch is kept upon the temperature and pulse and also on the condition of the joint, painful distension of which probably indicates infection. The synovial cavity is then at once aspirated with a syringe and the fluid examined. (*a*) If the fluid is quite clear or merely blood-stained, probably no serious infection is present. (*b*) If it is slightly turbid, infection is present and the joint should be washed out with sterile

saline solution and injected with penicillin streptomycin or other antibiotic The limb is placed on a splint and kept at rest For a knee joint a Thomas's splint with a light weight extension should be employed Reaccumulation of the fluid necessitates a repetition of the same procedure every day or two (c) If the fluid is from the first frankly purulent or becomes so a similar proceeding may be undertaken so long as the general and local symptoms are satisfactory and do not indicate any grave arthritic complications but if the swelling of the limb increases, as also the pain and fever then an arthrotomy may be required

Where the external wound is large and the joint is therefore probably infected from the first, its treatment must correspond to that of a gunshot wound, being carefully excised down to the lesion in the synovial membrane The margins of the rent in the membrane are cut away and the joint cavity washed out with sterile saline solution followed by an antibiotic. The cavity is now closed by interrupted sutures in the synovial membrane but the external wound is left open and lightly packed with Vaseline Gauze. Secondary suture of the skin may be possible in a few days.

The after-treatment of these cases is as for those of suppurative lesions of joints.

DISLOCATIONS

Congenital Dislocation. This is a dislocation due to a dysplasia or error of development and is present at birth. The hip joint is that most frequently affected (p 219) A *recurring dislocation* is one which develops again and again on the slightest provocation or follows any injudicious movement It is generally due to capsular relaxation or tearing, or to abnormality in the shape of the bones which articulate Repeated effusions following the dislocation may further stretch the capsule The shoulder and temporo-mandibular joints are those most often affected.

Pathological Dislocation. This is produced as the result of some intra articular affection, *e.g* tuberculous disease, septic arthritis, osteoarthritis or Charcot's disease.

Traumatic Dislocation. The causes are divided into predisposing and exciting. Under the former head may be included anatomical peculiarities such as the shallow socket of the glenoid cavity or some muscular or ligamentous weakness. Dislocations are rare in children since any violence directed to a joint or its neighbourhood is more likely to lead to an epiphyseal separation. In old people the bones become brittle and thus fractures, rather than dislocations, are produced hence the latter lesions are almost limited to adults and owing to their greater exposure to injury occur in men rather than women

The exciting causes are the application of external violence and muscular force, acting alone or in combination. The former may be direct, but is more commonly indirect, the force being applied at a distance from the joint Muscular action by itself can only produce dislocation in certain joints the head of the humerus, the patella and condyle of the jaw are the bones most often affected in this way If however the ligaments of a joint have been stretched by previous disease or displacement, recurrent dislocations from muscular action are not unusual

The term *complete dislocation* or *luxation* is applied to that condition in which the articular surfaces of the bones are completely separated from

one another An *incomplete dislocation* or *subluxation*, is one in which the surfaces are only partially separated

An *open dislocation* is one in which the skin has been ruptured and communication established with the exterior A *complicated dislocation* is one in which there has been some associated injury of vessels, nerves or viscera. The term *fracture-dislocation* is one applied to a condition in which a joint is rendered unstable by reason of a fracture of the constituent bones.

Physical Signs These are as follows (*a*) The evidences of local trauma pain, bruising and swelling of the soft tissues, due to their laceration and the effusion of blood into them (*b*) deformity due to the articular end of the displaced bone being in some abnormal position, where it can often be felt and sometimes seen (*c*) restricted mobility of the affected joint and hence impairment of function The degree to which this latter phenomenon obtains is necessarily variable, but as a rule it is very marked if however fracture is also present, passive movements may be possible, though associated with pain and crepitus.

Effects Those produced by a dislocation extend to all the structures entering into and surrounding the site of injury The ligaments are partially or completely torn, the bony surfaces are often fractured especially in closely fitting hinge-joints such as the elbow and ankle, the articular cartilage may be bruised or portions detached and neighbouring muscles and tendons lacerated and displaced Adjacent vessels and nerves are often contused or compressed. Considerable effusion of blood is always present.

The character of the injury explains the difficulties that are met with in its reduction. (*a*) The anatomical arrangement of the joint and its ligaments results in the hitching of bony prominences against one another while the head of the bone does not always lie opposite the hole in the capsule through which it originally passed. In a few cases the end of the bone may be grasped by neighbouring ligaments and tendons in such a way as to hinder its replacement. (*b*) Muscular contraction also constitutes an obstacle which, though it can be counteracted by suitable traction, is more effectively overcome by the use of an anæsthetic. Not only does the patient maintain the limb in a condition of rest by involuntary tonic contraction, but it becomes fixed by induration of the soft tissues.

When once reduced, there is usually little tendency for a dislocation to recur Reparative changes quickly manifest themselves, blood-clot is absorbed the rent in the capsule closes by cicatrization and in many cases no permanent lesion remains. In some, however the joint is left in a weak and relaxed state and liable to a recurrence of the displacement, while intra-articular adhesions, or the cicatricial contraction of the injured ligaments and muscles, may cause some loss of mobility After dislocation of the hip joint *avascular necrosis* of the femoral head may occur owing to damage to the blood vessels carried in the capsule of the joint.

If a dislocation is allowed to remain unreduced the true articular cavity becomes shallow and partly filled up by fibrous tissue while the displaced head of the bone becomes adherent to the structures among which it lies. As the result of a plastic inflammation either dense fibrous adhesions are formed or a new false joint (*pseudarthrosis*). The articular cartilage is softened while, owing to periosteal new bone the end of the shaft may be considerably deformed The portion of bone upon which the displaced head rests undergoes changes, partly atrophic (from pressure) partly hypertrophic

(as a result of periostitis) whereby a new socket is produced (Fig 13 17) Neighbouring muscles are secondarily shortened and accommodate themselves to the abnormal position of the limb while tendons which have been torn gain fresh attachments These changes necessarily interfere more or less seriously with the power of the limb and the movements of the joint Serious pain is often caused by pressure on neighbouring nerves.

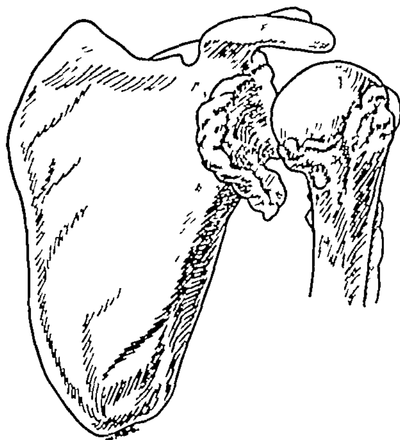


FIG. 13 17 OLD-STANDING SUBCORACOID DISLOCATION OF THE SHOULDER, SHOWING ATROPHY OF TRUE GLENOID CAVITY TOGETHER WITH FORMATION OF NEW JOINT AND ALTERATION IN SHAPE OF HEAD OF BONE (*Royal College of Surgeons Museum*)

Treatment The displaced bone should be reduced with as little delay as possible and to effect this two chief methods are employed manipulation and extension. *Manipulation* should always be used when practicable, less injury being sustained by the surrounding tissues. It consists in moving the limb in such directions as shall cause the displaced end to retrace the course that it has already taken through the rent in the capsule to its normal position. The shoulder and hip joints are more amenable to this method of treatment than hinge joints. Anæsthesia will be required in difficult cases and especially in dislocations of the hip joint. *Extension* is employed to overcome muscular and other forms of resistance, so as to allow the bone to slip back or be manipulated into its original position. In order to make this effectual, the parts above the dislocation are steadied by some counter extending force applied either by the hands of an assistant, or by a belt or towel, or by the knee or foot of the surgeon. Extension may be made by the

hands or a firmer grip may be maintained and greater force used by applying a bandage or towel to the limb

Reduction, however produced, is usually accompanied by a sudden and distinct snap or suction sound due to the contraction of muscles, unless the patient is deeply under an anæsthetic and the muscles are absolutely relaxed. The limb is subsequently kept at rest to allow the rent in the capsule to heal.

Unreduced Dislocations The treatment of an unreduced dislocation is often a matter of considerable difficulty Attempts at reduction are usually unsuccessful after two or three weeks. The greatest caution must be employed for fear of damage to main vessels or nerves.

The amount of mobility in an unreduced dislocation varies much in different cases and the character of the treatment is mainly governed by this. If movement is tolerably free and not particularly painful, massage and movements may be undertaken and a very useful limb result. Where however movement is both painful and limited operative treatment is desirable (*a*) Reduction by *open operation* consists in exposure of the joint, and the freeing of adhesions reduction may then be possible by means of manipulation or extension. In a few instances good function is obtained but as a rule the improvement is scarcely commensurate with the risks and difficulties of the operation especially if a considerable interval has elapsed since the accident. (*b*) *Excision* of the joint will often give a better result. In the elbow joint and shoulder it may be the only practicable method while in the hip an arthrodesis or arthroplasty may be the best solution

Open Dislocations. These are always serious lesions, for not only are adjacent vessels and nerves liable to injury but unless efficient treatment is adopted, suppurative arthritis ensues, leading to disorganization of the articulation, with subsequent ankylosis, or in the case of larger joints, possibly to death from sepsis or pyæmia.

Treatment This consists in applying the principles already enunciated for those of all serious lacerated wounds. The surrounding skin is first thoroughly cleansed the edges of the external wound excised including any gravely damaged soft tissues and the dislocation is reduced The deeper parts are examined and if need be washed with saline and the whole wound then closed or temporarily packed with a view to performing delayed primary suture. Antibiotics should be used. The bone, if much damaged, must be dealt with according to the instructions given for the treatment of open fractures, but immediate excision is probably desirable if retention of the damaged part is likely to be followed by ankylosis.

PHYSIOTHERAPY

It must be remembered that the surgeon's work is not completed when the immediate lesion for which he is responsible is repaired his duties also extend to the subsequent period of restoring functional activity to the parts involved Thus it is not enough merely to secure the union of a broken bone it is the duty of the medical attendant to take such precautions as shall prevent, if possible, the limitation of movement in neighbouring joints or to institute treatment for the removal of such stiffness, if it has unfortunately occurred. The excision of a cancerous breast is a beneficent operation, but the surgeon is doing no kind turn to his patient if he allows her to recover with an arm which is so fixed to the side that it can only be raised

with pain and difficulty a little forethought can prevent many a painful disability

The prolonged fixation of a limb causes many changes which the surgeon must carefully study if harmful effects are not to be produced In the first place the blood-supply suffers and this may result in defective nutrition and diminished resistance to bacterial infection Muscles become stiff from want of use and if the limb is the seat of hæmorrhagic extravasation, due to trauma or of septic inflammation extensive fibrous infiltration may follow Joints are not seriously disabled by prolonged immobility unless intra articular pressure due to weight-carrying or to muscular spasm, is super added, and then fibrosis of ligaments and thickening of the synovial membrane with the production of adhesions may result in limitation of movement or fixity in a bad position Still more likely is this to occur if periarticular inflammation of bacterial origin is in existence or if the patient is suffering from any marked degree of toxæmia Disuse atrophy of bone also occurs when rest is prolonged

Position. It is essential that if a limb is to be fixed in one position for any length of time that position shall be selected which will lead to as little subsequent disability as possible and shall permit rapid restoration of function when once the necessity for fixation has come to an end It must be remembered as a cardinal principle that *it is always easier to relax a stretched muscle or tissue than to stretch one that is contracted* and hence if particular structures are liable to contraction which will be difficult to overcome, these structures should be put on the stretch during the period of immobilization. A few specific illustrations will be useful (*a*) Prolonged fixation of the arm to the side is always liable to be followed by contraction of the pectoralis major and latissimus dorsi muscles, and much pain and discomfort have to be experienced before the arm is once again freely movable. This is likely to be aggravated in cases of axillary cellulitis or suppuration because cicatricial tissue may develop between or in the substance of these muscles In these cases the arm should always be kept at right angles to the trunk as has now been the custom for some years following radical mastectomy it is then easy when the time comes to drop the arm to the side If however there is a likelihood of osseous ankylosis occurring at the shoulder joint, the arm must not be kept away from the side for more than about half a right angle. (*b*) Grave limitation of movements of the wrist and fingers is always liable to follow prolonged immobility of the hand and if it is kept on a splint in the position indicated in Fig. 13 18 it is obvious that the hand



FIG. 13 18. HAND IN WRONG POSITION FOR PROLONGED FIXATION.

will be of little use if stiffness ensues. Whenever possible, the fingers and thumb should be left unbandaged so as to be free to move, and the wrist must be kept at rest in a slightly hyperextended position on a "cock-up splint. If the fingers and thumb must be immobilized the position to be

adopted should be, if possible, that indicated in Fig. 13 19 *i.e* as if the patient were attempting to pick up a large ball. (*c*) In conditions involving prolonged fixity of the forearm the hand should be kept in a position of full supination



FIG 13 19 HAND IN CORRECT POSITION FOR PROLONGED FIXATION.

otherwise the supinators become stretched, the pronators are contracted, and subsequent supination, always the weakest movement of the forearm, almost an impossibility If however it is probable that subsequent rotation of the forearm will be entirely lost, the hand should be kept almost midway between pronation and supination but an exception to this rule must be made for the shorthand typist who needs a pronated hand to operate the keyboard When determining the best position for fixation, the type of work for which the patient is fitted as well as personal convenience should be taken into account. (*d*) Whenever it is likely that the development of scar tissue will lead by its inherent contractility to subsequent deformity the limb should be placed, if possible, in a hyper-corrected position so as to allow for contraction. Prevention of a deformity by the surgeon's forethought is always better than its cure by the most ingenious skill.

Massage. Massage, or the manipulation of soft tissues, requires special training to acquire the requisite manual dexterity but all doctors should know the principles governing its application. The manipulations employed comprise stroking (effleurage) kneading (pétrissage), counter-irritation (tapotement), frictions and vibrations. *Stroking* is carried out with the flat of the hands and a firm centripetal movement is used to assist the superficial venous return whilst light centrifugal stroking will promote relaxation of painful and spastic muscles. Talcum powder is used to reduce friction, but olive oil may be employed if the skin is abnormally dry or an embrocation if counter-irritation is indicated *Kneading* consists of picking up the deep structures and squeezing gently but firmly to assist the deep circulation or moving them transversely to overcome fixation by scar tissue. *Counter irritation* is produced by a rapid series of light blows perpendicular to the surface delivered by the ulnar side of the open hand (hacking) or by the cupped hands (clapping) When skilfully employed the cutaneous nerve-endings are stimulated and the circulation increased without discomfort. *Frictions* are applied by firm pressure of the finger tips working backwards and forwards across the fibres of aponeurosis with the object of dispersing exudates and increasing the local circulation. These transverse or deep frictions, as they are called, are used in the treatment of fibrositis and sprains of ligaments. *Vibrations* are produced by a rapid movement of the operator's hands or delivered by a mechanical vibrator The former may be applied to the ribs at the end of an expiratory movement to promote coughing, and

are sometimes known as shakings the latter is used to render insensitive a painful neuroma such as may occur in an amputation stump

A typical treatment by massage occupies about twenty minutes and consists of a period of stroking followed by kneading, then any special manipulations required and terminates with a few minutes of counter irritation The main indications for massage are to maintain the circulation in a paralysed limb to reduce œdema to relieve pain and spasm in contused muscles, to promote the absorption of exudates in aponeurosis and to mobilize scar tissue

Manipulation of Joints. Stiffness of joints may be due to prolonged immobilization to the formation of adhesions to fibrosis and contracture of the synovial membrane and capsule to the inhibition of movement by pain and protective muscle spasm, or to hysteria It may be necessary to manipulate joints to prevent stiffness occurring during prolonged splinting or in a paralysed limb (prophylactic or passive movements) to break adhesions to stretch a contracted capsule or for diagnostic purposes. Manipulations may be carried out with or without anæsthesia, depending on the co-operation of the patient and the degree of force which must be used Before manipulating a joint it is necessary to secure muscular relaxation by comfortable support and warmth. In addition, massage is often helpful in promoting relaxation. The active and passive range of movement within the limits of pain should be noted and if it is found to be limited in one or two directions only then intra articular adhesions are likely but if movement is limited in all directions, the probable explanation is a contracture of the capsule. In the former a sharp snapping manipulation is likely to succeed but an anæsthetic is often necessary In the latter a sustained stretching movement is required and frequent manipulations without anæsthesia are preferable because too much force may cause tearing of tissue, hæmorrhage and subsequent fibrosis. As a preliminary to all manipulations, a few minutes should be spent separating the joint surfaces and stretching the capsule by a sustained stretching pull in all directions It is important to remember to carry out the antero-posterior and lateral gliding movements which are not under voluntary control, but are nevertheless essential for full function Manipulations of joints should be followed without delay by frequent remedial exercises and heat should be applied as long as pain persists.

Remedial Movement and Exercises. There are limits to the usefulness of massage and joint manipulation as remedial agents because the effective restoration of the function of muscles and joints can only be brought about by active movement. In the past the medical profession has been unduly conservative and cautious in this direction. In the presence of inflammation rest is of primary importance and movement should be limited to the minimum which is possible and justifiable to prevent stiffness, but once inflammation has subsided the patient should be urged to restore function by his own efforts. The introduction of antibiotic substances has made it possible to control inflammation quickly in the majority of cases, so that nowadays there is little excuse for the atrophy of muscles and stiffness of joints which caused so much disability in former times.

Passive movements are used to prevent stiffness, and are carried out by the operator when it is impossible or undesirable for the patient to assist movement, as, for example, in flaccid paralysis or when complete rest is

prescribed after coronary thrombosis. *Relaxed movements* are employed in spastic paralysis and in the presence of muscle spasm due to pain. The patient is taught how to relax whilst the operator carries out passive movements *Assisted movements* are introduced as soon as paralysed muscles begin to recover or pain causing inhibition of movement has been relieved. Assistance may be required if a muscle is too weak to move the part against gravity or if the effort of doing so causes undue discomfort. The methods employed include support in slings or in water manual assistance by the operator or movements in the horizontal plane on a board lubricated by French chalk. *Resisted movements* provide for the progressive restoration of muscle power In the early stages small weights or light springs are introduced in suitable pulley circuits or the operator can give increasing manual resistance. As soon as a muscle can overcome gravity free movements or remedial exercises are possible, and further strengthening of the muscle is then achieved by increasing the number of contractions against gravity In the later stages, vigorous weight and pulley exercises are used to restore full power

Group Remedial Exercises and Games. These play an important part in the restoration of function. During all but trivial illness, muscle strength, manual dexterity and mental concentration deteriorate through disuse and the process is greatly accelerated by toxæmia It is necessary to restore not only the disabled part, but also physical and mental fitness as a whole, and to the extent that the patient is fit to return to a normal day's work without undue fatigue. There is a wide variation in the agility manual dexterity muscular strength and mental concentration required in various occupations, such as builder postman, mechanic, docker labourer clerk etc. Full recovery depends therefore on a progressive build up of physical and mental function according to individual requirements. Ideally this should be done by a gradual resumption of work, but this is seldom possible under industrial conditions. Therefore use is made of the gymnasium and occupational therapy departments to provide increasing periods of activity until in the final stages of convalescence the restoration of function may become a full-time occupation in itself

Group activity stimulates competition, and the boredom of sustained remedial exercises can be relieved by the introduction of a great variety of games which, if suitably selected, achieve the desired therapeutic movement and at the same time distract the patient's attention from the disabled part. A deliberate exercise designed to overcome a particular disability may fail because pain or fear of pain inhibits activity but if the movement is spontaneous the anticipation or appreciation of pain is greatly reduced. For instance, a patient with a stiff shoulder joint may make a poor showing at raising the arms above the head but if asked to bounce a ball downwards on to the floor as hard as possible the arms are raised involuntarily above the head in order to get the maximum downward force When done in the form of a class competition to see who can bounce the ball the highest the range of movement attained is often surprising.

Occupational Therapy This makes use of crafts to assist the restoration of movement, muscle power and functional activity in the disabled part and the body as a whole whilst the attention of the patient is concentrated on the creative work in hand. Occupational therapy is employed also to relieve boredom and maintain functional activity for patients confined to

bed for long periods, such as those with a fractured femur or surgical tuberculosis. By using slings to support weak muscles and springs to assist movement it is possible for severely disabled patients to engage in handicrafts and to produce a finished article of good quality whilst at the same time assisting the recovery of function. Weaving is a craft which can be adapted in many ways, and poliomyelitis an example of the type of disability for which it is particularly useful. In the later stages of convalescence it is desirable that the patient should progress from the therapeutic and leisurely atmosphere of light handicrafts into a workshop more closely simulating industrial conditions. Thus, in addition to a light handicraft room most occupational therapy departments have a wood and metal workshop in which the work done is still selected to further the recovery of function but at the same time noise and hard work are the order of the day.

Medical Rehabilitation. Enough has been said to show that much may have to be done in the after-care of surgical cases. The object of a good surgeon is to fit his patient to return to his normal work without disability or undue delay. In the majority of cases this is achieved by surgical forethought and guidance, the co-operation of the patient and the assistance of the rehabilitation techniques, to which brief reference has been made. In a minority of cases, however, some degree of permanent disability is unavoidable, such as the loss of a limb or permanent paralysis of muscles. The patient may be unable to return to his normal work and will require training for a new vocation within his residual capacity.

Industrial Resettlement. The successful rehabilitation of all cases, including those with an unavoidable permanent disability, is so important to the surgeon that a surgical text book is not complete without a brief reference to the Disabled Persons (Employment) Act, 1944. Under this Act the Ministry of Labour have established (*a*) registration of all persons with a substantial and permanent disability. About one million persons are registered out of a working population of around 14 millions, but only 10 per cent. of those registered require the help provided by the Act; (*b*) vocational training centres for those unable to return to their normal work; (*c*) Industrial Rehabilitation Units (I.R.U.), wherein a period of physical and industrial reconditioning is provided for those whose working capacity and skill have seriously deteriorated as a result of a long illness; (*d*) an obligation on all employers of more than twenty workpeople to give priority of employment to a quota (at present 3 per cent.) of registered disabled persons; (*e*) specially trained disablement resettlement officers (D.R.O.) at all employment exchanges to assist registered disabled persons to find suitable employment; (*f*) Disabled Advisory Committees (D.A.C.) throughout the country to seek the co-operation of employers and trades unions with a view to finding suitable work for the registered disabled persons of the district; and (*g*) sheltered workshops for those too disabled to work under normal industrial conditions.

Chapter 14

INJURIES OF THE UPPER LIMB

Fractures and Dislocations of the Clavicle

No bone in the body with the exception of the radius, is broken more frequently than the clavicle *this is due to its exposed position and its buttress-like action* in keeping out the point of the shoulder so that every shock to the arm is transmitted through it to the trunk. Although sometimes broken by direct violence, fracture is usually due to force directed to the hand or shoulder and hence is common in falls from horseback, occurs frequently in jockeys, on the hunting-field, or among recruits in mounted corps. It is more common in men than in women and in children is often a green-stick fracture. The bone is usually fractured in its middle third, but occasionally fractures are seen at the sternal or acromial ends

Middle Third Fractures. This is the commonest site. The bone yields about its centre, or a little external to it and the line of fracture is slightly oblique running from before backwards, downwards and inwards. The displacement is quite characteristic. It is present in any fracture situated between the rhomboid ligament on the inner side and the coracoclavicular ligaments *on the outer being less marked however* when the fracture is nearer the extremities than in the centre of this space The patient gives a history of injury and severe pain, supports the elbow with the other hand, the *head being bent over to the affected side to relax the muscles of the neck* the arm is powerless. The point of the shoulder is less prominent than usual, being approximated to the middle line and on a lower level than the other while at the site of fracture the inner fragment projects. *This deformity* is accounted for by a displacement of the whole outer fragment downwards, forwards and inwards (Fig. 14 1), the outer end being, however more dis



FIG 14 1 FRACTURE OF THE MIDDLE THIRD OF THE CLAVICLE.

placed than the inner This is mainly due to the weight of the arm acting upon the outer fragment when the buttress-like action of the bone is gone for muscular action has little effect The position of the inner fragment is little altered since it is held in place by the rhomboid ligament the apparent projection of its outer end is mainly due to the depression of the outer fragment.

Treatment Where there is little or no displacement, all that is needed is to immobilize the arm in a sling In a green-stick fracture the deformity can be remedied by manipulation and the arm bandaged to the side. In fractures with displacement the aim is to elevate the shoulder and to draw it backwards. The *three-handkerchief method* may be used or some variation of it Two large handkerchiefs folded double and rolled into bands, are placed vertically one over each shoulder and under each axilla each is lightly knotted behind and the ends firmly tied to the opposite handkerchief across the middle line By this means the point of the shoulder is kept outwards and backwards. The third handkerchief is used as a sling, the elbow



Fig. 14 2. The "Three Handkerchief" Method of Treating a Fractured Clavicle.

being kept forwards and the hand placed over the sound clavicle. Daily attention is required to maintain adequate reduction and to prevent the bandages from becoming loose. Non-union rarely occurs, while malunion, though possibly unsightly has little effect upon function Maintenance of finger elbow and shoulder movement is of paramount importance and in the elderly must take priority over treatment of the clavicle itself Subsequent stiffness of these joints is due to immobility and not to the primary injury

Sternal End Fractures. These rare fractures are not accompanied by gross displacement, stability being maintained by the rhomboid ligament.

Acromial End Fractures. These fractures are sometimes impacted and may be mistaken for subluxations of the acromioclavicular joint. The outer fragment remains attached to the acromion process.

Treatment Adhesive strapping should be applied as for an acromioclavicular dislocation.

Complications are rare. *A bone spicule* may perforate the skin, or may be felt subcutaneously If after some weeks it does not become rounded off, it should be removed through a small incision. The *supraclavicular nerve* may be involved and become the source of temporary pain. Injury to the

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FIG. 14 — THE "THREE HANDKERCHIEF" METHOD OF TREATING A FRACTURED CLAVICLE.

being kept forwards and the hand placed over the sound clavicle Daily attention is required to maintain adequate reduction and to prevent the bandages from becoming loose. Non-union rarely occurs, while malunion though possibly unsightly has little effect upon function. Maintenance of finger elbow and shoulder movement is of paramount importance and in the elderly must take priority over treatment of the clavicle itself Subsequent stiffness of these joints is due to immobility and not to the primary injury

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subclavian vein, brachial plexus or dome of the pleura is rare and is only likely to happen in cases of severe direct violence or gunshot wounds.

Dislocation of the Sternal End of the Clavicle. In spite of the apparent weakness of this joint and the great strains to which it is subjected, dislocation is uncommon, owing to the strength of the ligaments surrounding it, particularly the rhomboid The clavicle is more easily broken than displaced The cause of these dislocations is always violence directed to the outer end of the bone. The inner end of the bone is generally displaced *forwards* The end of the bone lies on the anterior surface of the manubrium where it can be easily detected all the ligaments of the joint are torn, except, perhaps, the interclavicular The point of the shoulder is approximated to the middle line

Backward and *upward* dislocations are both extremely rare, and in each pressure symptoms on the trachea and great vessels of the neck may be produced Reduction is effected as in the forward displacement, or by levering the inner end of the clavicle outwards by manipulating the arm over the surgeon s knee placed as a fulcrum in the axilla.

Treatment Reduction is effected by placing the knee against the spine between the scapulæ and drawing the shoulders backwards, the elbow on the affected side being kept in front of the mid-axillary line. To prevent recurrence a pad of felt or sponge rubber is carefully moulded over the end of the bone and fixed by strips of plaster The arm is then put up as for a fractured clavicle. Disability is slight even if the dislocation remains partly unreduced

Dislocation of the Acromioclavicular Joint. This is caused by a fall on the point of the shoulder The common type is a subluxation, in which the outer end of the clavicle is prominent, but the coracoclavicular ligaments are not completely ruptured. Reduction is easy but maintainance of the normal position difficult. A felt pad is placed over the outer end of the clavicle and another over the olecranon Great care is necessary to protect the ulnar nerve. The two pads are approximated by many layers of adhesive strapping which pass from the clavicle down the front of the arm, round the olecranon and up the back of the arm to the shoulder once more. The strapping is inspected weekly and reinforced when necessary It is retained for three weeks and the forearm rested in a sling. The functional result is excellent, but some deformity may remain. The rare luxation is associated with complete rupture of the coracoclavicular ligaments and is easily diagnosed by the excessive mobility of the outer end [illegible] lavicle. Repair by conservative means [illegible] ly and the injury [illegible] pen operation. A new ligament is fas[illegible] f fascia or tend [illegible] clavicle lashed down to the coracoid. [illegible] ort may be pro [illegible] ans of a screw passing through the cl[illegible] to the base of [illegible] process.

Fractures of the Coracoid Process. This part of the bone is rarely fractured The injury may be due to avulsion by muscular violence or by ligamentary pull in connection with an acromioclavicular dislocation

Fractures of the Body The scapula is broken by direct violence directed to the spinous process or infra spinous fossa A linear or comminuted fracture may result Displacement is usually slight and the diagnosis difficult except by radiography owing to the resulting hæmatoma

Fractures of the Neck These fractures are rare (Fig 14 4) but may result from severe violence applied to the shoulder The small fragment including the glenoid cavity may be displaced downwards by the weight of the arm.



FIG. 14 3 FRACTURE OF THE BODY OF THE SCAPULA.



FIG 14 4 FRACTURES OF THE NECK OF THE SCAPULA.

A Through the glenoid fossa B through the anatomical neck C, through the surgical neck.

Fractures of the Articular Margin of the Glenoid. This portion of the bone may be fractured and may be associated with dislocation of the joint it may also be a predisposing cause of recurrent dislocation of the shoulder

Dislocation of the Shoulder Joint

This occurs almost as frequently as all the other dislocations of the body put together The shallowness of the glenoid cavity the size of the head of the humerus, the laxity of the capsule, the extent and force of the movements possible, and the exposed position of the shoulder explain the great frequency of the accident. It usually results from falls upon the hand or elbow the arm at the time of the accident being widely outstretched The anterior or inferior part of the capsule yields, the head of the bone being primarily displaced forwards (*subcoracoid* or *subclavicular*) or occasionally downwards (*subglenoid*) rarely the humeral head slips backwards into the *subspinous* position.

Physical Signs The signs of a dislocation of the shoulder are sufficiently obvious and certain characteristic features are present in almost all varieties. (*a*) The shoulder looks flattened, owing to displacement of the head inwards (Fig. 14 5) and as a result of this the acromion process is unduly prominent, and a hollow is felt below it. (*b*) The head of the bone lies in some abnormal position and the glenoid cavity is empty (*c*) The elbow is displaced away from the side, it is impossible to make it touch the chest wall at the same time that the hand is placed on the opposite shoulder (Dugas test) this does not always apply in the subcoracoid type (*d*) The vertical measurement round the axilla is increased in all the varieties (Callaway s test) while inspection reveals a lowering of the anterior or posterior axillary fold (Bryant s test) (*e*) A ruler or straight-edge can be made to touch both the acromion process and the outer condyle of the elbow in most cases of dislocation (Hamilton s ruler test) this is impossible when the head of the bone is in its normal position, but can also occur in fractures of the anatomical neck. (*f*) The joint cannot be moved. (*g*) Radiography will show that a

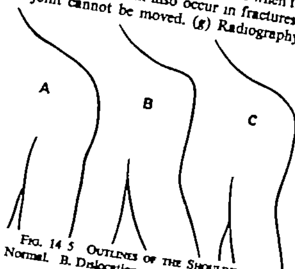


FIG. 14 5 OUTLINES OF THE SHOULDER.
A. Normal. B. Dislocation. C. Abduction fracture.

dislocation is present. In difficult cases, both antero-posterior and lateral projections must be taken. The latter is really a projection taken with the tube directed into the axilla and the film placed above the shoulder joint. Stereoscopic views may also be of help.

Subglenoid Dislocation. The head of the bone passes down into the axilla, resting against the outer border of the scapula below the glenoid cavity between the subscapularis above and the teres minor below with the long head of the triceps behind (Fig. 14 6) The capsular ligament and muscles passing to the tuberosities are torn, while the axillary vessels and nerves may be seriously compressed, leading to numbness of the fingers The head of the bone is felt in the axilla, and the anterior axillary fold is much lowered the elbow is directed away from the side and slightly backwards the arm is lengthened, perhaps to the extent of 1 inch (2 5 cm.) while the forearm is usually flexed The lower edge of the glenoid cavity is sometimes broken off when reduction with crepitus is easily accomplished, but the displacement as readily recurs.

In a few cases the arm has been abducted and displaced vertically upwards, although the head of the bone was in the usual position of a subglenoid dislocation, constituting the luxatio erecta.

The subglenoid position is unstable and the humeral head usually slips forwards into the subcoracoid position

Subcoracoid Dislocation. This is the most common variety (Figs 14 7 and 8) The head of the bone lies under the coracoid process on the anterior

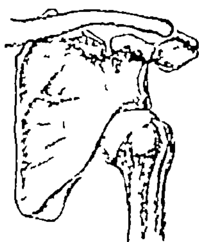


FIG. 14 6. SUBGLENOID DISLOCATION OF THE SHOULDER.

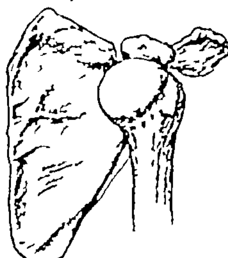


FIG. 14 7 SUBCORACOID DISLOCATION OF THE SHOULDER.

part of the neck of the scapula, immediately in front of the glenoid cavity the anatomical neck impinging on its anterior border In this position it lies over the tendon of the subscapularis, which is either torn or stretched across the neck as a tense band, considerably impeding reduction. The muscles attached to the great tuberosity may be stretched, resulting in marked external rotation of the limb, or they are torn, or the great tuberosity itself is pulled off, the humerus being then rotated inwards. The elbow is displaced backwards and outwards and the head of the bone can be felt on rotation of the arm under the outer third of the clavicle. Little alteration is produced in the length of the arm

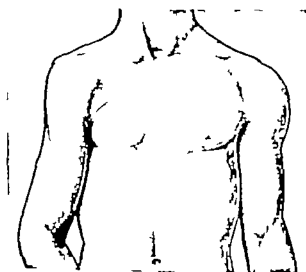


FIG. 14 8 SUBCORACOID DISLOCATION OF THE SHOULDER.



FIG. 14 9 SUBSPINOUS DISLOCATION OF THE SHOULDER.

Subclavicular Dislocation. This is uncommon and merely an exaggeration of the subcoracoid The head of the humerus passes further inwards and lies deeply under the pectoralis minor on the second and third ribs. The elbow is markedly separated from the side and directed a little backwards, distinct shortening is present.

Subspinous Dislocation. This is unusual (Fig. 14 9) The head lies in the infraspinous fossa, immediately behind the glenoid cavity between the infraspinatus and teres minor muscles, the subscapularis being generally torn. The elbow is displaced considerably forwards but can be made to touch the chest wall the arm is rotated inwards, so that the hand is thrown across the front of the body There is usually a marked hollow in front of the shoulder while a prominence is caused behind by the head of the bone in its false position. The length of the arm is often unaffected but if any change is present, it is slightly lengthened

Treatment of Dislocation of the Shoulder This consists in reduction by manipulation or extension

For *reduction by manipulation* an anæsthetic is desirable but not always essential Many methods have been suggested, of which the following are the more important Usually when the muscles are relaxed any slight rotary movement suffices to " put the bone in "

Kocher s Method for Subcoracoid Dislocation The surgeon, standing in front of his patient, who is seated or reclining and supported by an assistant, grasps the flexed elbow with one hand, and by leaning on this

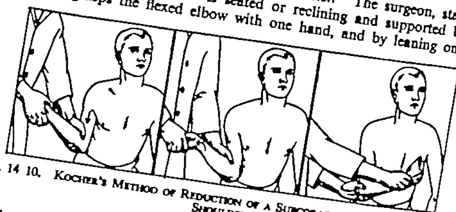


FIG. 14 10. KOCHER'S METHOD OF REDUCTION OF A SUBCORACOID DISLOCATION OF THE SHOULDER.

produces slight extension With the other hand he grasps the wrist and rotates the arm firmly and steadily outwards as far as it will go the elbow being pressed to the side (Fig. 14 10) Distinct resistance will be felt, due to the contraction of the subscapularis which must be stretched. The elbow should be drawn steadily forwards as far as it will go with the humerus still fully everted Finally the arm is rotated inwards so as to carry the hand towards the opposite shoulder All these movements should be carried out steadily and evenly without undue force or jerking for fear of fracturing the surgical neck of the bone.

For *reduction by extension* different methods are employed, the object being to overcome the tension of surrounding ligaments and muscles. It may be applied directly downwards by the surgeon grasping and pulling on the arm, while his unbooted foot is used as a counter-extending force in the axilla the patient lying flat on a mattress placed on the ground and the surgeon sitting by the side. Another plan consists in using the knee as a

fulcrum instead of the heel, the patient sitting in a chair one assistant makes traction on the limb abducted to a right angle, while another makes counter extension and steadies the scapula In all methods of direct extension great care must be taken to avoid further damage to vessels and nerves.

Complications These are (*a*) fractures of the glenoid margin great tuberosity or neck of the humerus (*b*) compression of nerves, usually the circumflex, with resulting paralysis of the deltoid muscle (*c*) habitual dislocation

After treatment The arm is then placed in a sling to support the elbow and kept to the side by a bandage or beneath a vest. In young people, no movements are permitted for three weeks but in the elderly active movements are allowed after three days The sling should be continued for three weeks lest the weight of the arm cause subluxation of the humeral head downwards. Restoration of tone in the deltoid is important and static contractions or faradism are given from the outset.

Association fracture of the lower margin of the glenoid cavity requires more careful and prolonged fixation, so as to prevent recurrence of the trouble When the dislocation is complicated by fracture of the great tuberosity radiography will be essential in order to test the position of the head of the bone and of the fragment if this is unsatisfactory open operation to fix the tuberosity by screw or bone peg must be undertaken.

Recurring or Habitual Dislocation of the Shoulder This is an annoying condition in which the head of the bone slips out of place. It is due either to irregular shape of the head, or an unhealed tear in the anterior part of the capsule (*Bankart s lesion*), possibly due to too early and vigorous mobiliza tion after a traumatic dislocation It is more common in those subject to epileptic fits. Prevention is possible if the patient can remember never to undertake certain movements, *e g* hyper-abduction of the arm, as in doing the hair more often relief by operative measures will be acceptable.

Treatment Bankart s operation aims at the repair of the capsular tear or its reattachment to the margin of the glenoid, from which it may be torn.

The Putti Platt operation is a plastic procedure on the subscapularis tendon. This is divided and the short stump fixed to the front of the glenoid while the main portion is overlapped and sutured to the lesser tuberosity

Nicola s operation makes use of the long head of the biceps, to form an internal ligament. The tendon is divided in the bicipital groove, and the proximal end threaded through a hole drilled in the humeral head, and made to emerge in the groove, where the tendon is reattached to itself and to the neighbouring periosteum.

The first two operations give good results, the recurrence rate being approximately 5 per cent., whereas the recurrence rate in the third is about 30 per cent.

Rotator Cuff Injuries. These are described on p 188 in chapter 10.

Fractures of the Upper End of the Humerus

Fractures of the Neck of the Humerus. These should be divided into those associated with *adduction* of the lower fragment and those accom panied by *abduction* They are usually due to blows or falls on the shoulder less commonly to indirect violence and occur more often in elderly people than in the young. The shoulder becomes greatly swollen from effusion of blood pain on movement is severe, but crepitus may perhaps be felt on

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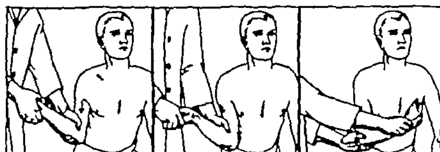


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rotating the arm. There is usually about half an inch of shortening. In most cases the upper fragment is not totally detached but remains connected with the rest of the bone by a few shreds of capsule, so that necrosis is prevented. It is often *impacted* into the lower fragment and deformity is slight. If it is completely detached, the small upper fragment is often rotated on its own axis and even dislocated into the axilla. Distinction between these fractures and a dislocation of the shoulder joint is sometimes difficult, especially where bruising and swelling obscure normal landmarks. A skiagram (Fig. 14 11) will confirm the diagnosis one way or the other and the shortening of the arm when measurement is taken from the acromion process to the olecranon, the presence of the head in the normal position and the absence of any depression just below the acromion process should serve as diagnostic points.



FIG 14 11 FRACTURE OF THE NECK OF THE HUMERUS WITH ABDUCTION OF THE LOWER FRAGMENT

Treatment In the elderly it is unwise to disimpact the fracture, as the deformity is seldom severe. An axillary pad of wool, a sling and a bandage to keep the arm against the chest wall, is all that is required. Active movements of the fingers, wrist and elbow must be encouraged, and the shoulder may be moved in a few days The sling can be discarded in three to four weeks. Full movements are difficult to restore, abduction being the most obstinate In younger patients, severe *adduction deformity* should be corrected under an anæsthetic by fully abducting the arm, which is then placed on an abduction frame or in a plaster spica, for four weeks. Continuous traction may be necessary if the head is loose. An *abduction deformity* is corrected by placing the closed fist in the axilla to act as a fulcrum over which the arm is brought down to the side. After correction an axillary pad and sling are used and the arm bound to the side.

Fractures of the Great Tuberosity This may be injured by direct violence (contusion fracture) or by avulsion (avulsion fracture). Treatment of the contusion variety is by a sling for a few days, followed by early movement.

In the avulsion fracture the separated fragments may be brought together either by fixation of the arm on an abduction frame or by open operation

Separation of the Upper Epiphysis. This occurs up to the age of eighteen to twenty years and involves the head and both the tuberosities. The upper end of the shaft is somewhat conical in shape the apex of the cone fitting into a depression in the middle of the epiphysis The lesion usually follows the epiphyseal line but there is always a spike of bone detached from the diaphysis A bridge of intact periosteum may help to limit displacement of the upper fragment. The shaft usually travels forwards, its upper end projecting so as to be felt or even seen beneath the skin an inch or more below the coracoid process occasionally a well marked inward displacement is superadded so that the condition somewhat resembles a subcoracoid dislocation. The presence of the head of the bone in the glenoid cavity should prevent this mistake while the softness of the crepitus distinguishes it from a fracture.



FIG 14 12. SEPARATION OF THE EPIPHYSIS AT THE UPPER END OF THE HUMERUS WITH FRACTURE OF THE DIAPHYSIS. ADDUCTION DEFORMITY

Treatment It is most important to reduce this displacement, since otherwise interference with the growth of the limb is almost certain to ensue This may be effected by traction upon the arm under an anæsthetic. The arm is then brought forward in front of the chest. If the fragments are stable in this position a plaster spica is applied to fix the arm in full forward flexion and abduction. If this manœuvre fails, operative reduction and fixation should be undertaken

Fracture-Dislocation of the Upper End of the Humerus. A fracture combined with dislocation of the head of the bone is not a very common accident. The fracture is generally more or less oblique and passes through the greater tuberosity or involves the surgical neck.

It is produced by severe direct violence, as by a person pitching with great force on the shoulder The head of the bone is first forced into the axilla through a rent in the capsule, the tendons attached to the tuberosities being stretched or torn, fracture of the neck follows. Unless seen early

hæmorrhagic effusion makes diagnosis difficult and almost impossible apart from stereoscopic radiography If unreduced the displaced head of the bone may remain loose, or union may occur with much deformity and the production of many adhesions. Injury to the radial nerve or brachial plexus may be a complication. The axillary artery may be damaged

Treatment Attempts should be made to reduce the dislocation, steady traction being exerted on the abducted arm by an assistant while pressure is made by the surgeon over the head of the humerus in the axilla The angle of abduction must be above 90 so as to bring the humeral shaft into line with the fractured surface of the head of the humerus (140° was recommended by Robert Jones)

Open operation may be required if conservative methods fail, but carries a high risk of avascular necrosis of the head of the bone If possible it should be replaced but if detached from its blood supply it may be removed A pseudarthrosis will result and a useful but limited range of movement may be expected



FIG. 14 13 HANGING CAST FOR FRACTURE OF THE SHAFT OF THE HUMERUS. Note felt pad over olecranon. The encircling turns of soft bandage have been omitted.

Fractures of the Shaft of the Humerus

These fractures may be either spiral or transverse.

Spiral Fracture of the Shaft. This is caused by torsion and occurs in the middle third of the humeral shaft. Pain swelling and loss of function make the diagnosis obvious. There may be some shortening and crepitus can be felt. Severe angular deformity is unlikely

Treatment The use of a "hanging cast" gives sufficient traction to overcome the shortening and enough immobilization to make the patient comfortable (Fig. 14 13) A U shaped plaster slab is applied from the axilla

to the acromion and retained in position by a few turns of cotton bandage Care must be taken to avoid pressure on the ulnar nerve at the elbow A pad of wool is placed in the axilla and the arm bound to the chest wall The forearm is supported by a collar and cuff Clinical union will be present in four to six weeks Movements of the fingers forearm and elbow should be encouraged from the beginning.

Transverse Fracture of the Shaft This is the result of direct violence the fracture may occur in the middle or upper third of the shaft Loss of function, swelling and crepitus make the diagnosis easy there may be defor mity The deformity depends upon the site of the fracture. If between the



FIG. 14 14 FRACTURE OF THE SHAFT OF THE HUMERUS.
Fixation by intramedullary nail. At operation the radial nerve was found between the fragments.

insertion of the deltoid and the bicipital groove the upper fragment will be drawn inwards and the lower fragment upwards and outwards. If below the insertion of the deltoid, the upper fragment will be abducted and the lower fragment drawn inwards

Radial nerve injury is common and should be looked for before treatment is started.

Treatment Reduction is obtained by manual traction and manipulation with the elbow bent to a right angle. It may be possible to " hitch " the fragments together but the fracture is unstable. The shoulder humerus and forearm are immobilized in a plaster spica, in a position of 60° of abduc tion and mid rotation. The arm should be 20° forward of the coronal plane of the body Transverse fractures are slow to unite and fixation for *ten to*

and the fragments manipulated into position. Flexion of the elbow locks the fracture by the tension of the triceps behind and the apposition of the soft parts in front. This position is maintained by a collar and cuff, which may in some cases be reinforced by the application of a posterior plaster slab extending from the axilla to the wrist. Too great flexion combined with subsequent swelling may obstruct the circulation, which may result in ischæmic necrosis of the forearm muscles. *Volkmann's contracture* is thus produced. Great care is required to be certain that the radial pulse can be felt at the wrist and that the fingers are not blue or cold. If vascular obstruction is suspected, the amount of flexion must be reduced and in any case the child should be kept under strict observation for a few days after reduction of this fracture. As the swelling gets less, gradual increase of the flexion may be obtained by daily tightening of the collar and cuff. If this is not done, stability may be lost and the fracture may slip. At the end of four weeks, the fixation may be discarded and *active* movements allowed. No physiotherapy is required and full movement should be regained in a few months. The presence of pain, lack of progressive improvement in the range of movement or the feeling of a lump in front of the elbow should suggest the onset of *traumatic myositis ossificans* which can be confirmed by radiography. A shadow of ossification will be seen in the brachialis muscle. Further immobilization in a sling will then be necessary until the new bone has been absorbed. *Active movements* may then be allowed.

T- or Y-shaped Fractures. These usually occur as a result of direct injury. In a T-shaped fracture a longitudinal fissure extends into the joint through the centre of the lower fragment of a supracondyloid fracture; in a Y shaped fracture the fissure starts at the articular line and bifurcates above so as to

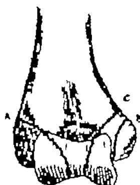


FIG. 14 16. FRACTURES OF THE CONDYLES OF THE HUMERUS.
A, of lateral condyle. B, of medial epicondyle. C, of medial condyle.

detach both condyles. Sometimes the fragments are not completely detached and then, although there is much bruising and pain, crepitus is not obtainable; at other times the condyles are separated completely and will move on each other with crepitus, the elbow being increased in breadth. Displacement of the forearm laterally (usually outwards) often accompanies this lesion. Great swelling and ecchymosis rapidly develop and diagnosis, apart from radiography, is often difficult.

Treatment. When there is no displacement, the elbow is flexed by a collar and cuff for three weeks; but when they are completely detached attempts to replace the fragments are usually unsuccessful. It may be wise

to operate in order to remove the blood and enable the fragments to be manipulated into position and fixed there by screws or wires

Fractures of the Condyles. These usually result from direct injury though the lateral condyle is sometimes broken by indirect violence such as a fall on the hand, since the laxity of the elbow joint on this side allows considerable mobility between the radial head and the capitellum of the humerus

(1) *Fracture of the Lateral Condyle* This fracture always involves the elbow joint and is more common than that of the medial condyle The line of fracture runs from the condyloid ridge downwards and inwards so as to separate the capitellum or even to encroach upon the trochlear surface (Fig 14 17) The fragment is rotated forwards and can be felt to move inde pendently with crepitus, which may also be produced by rotation of the hand and radius. The accident is associated with much pain and ecchymosis



FIG. 14 17 FRACTURE OF THE LATERAL CONDYLE OF THE HUMERUS.



FIG. 14 18 FRACTURE OF THE MEDIAL CONDYLE.

(2) *Fracture of the Medial Condyle* This may be intra or extra-capsular The *extra-articular* variety (Fig. 14 16, B) consists of a mere displacement of the epicondyle and in young people is probably a separation of epiphysis which remains distinct from the shaft till the age of eighteen or nineteen years (Fig. 14 19 G). The small fragment is drawn a little downwards by the muscles attached to it and may be associated with injury of the ulnar nerve. The *intra-articular* form (Fig. 14 16 C) is the less common and extends from the condyloid ridge to the trochlear surface, involving the coronoid and olecranon fossæ. The fragment is displaced a little upwards and back wards, the ulna usually accompanying it, so that on extending the elbow the olecranon appears unduly prominent, the lower end of the humerus projects anteriorly and the forearm is slightly adducted (cubitus varus) The ulnar nerve may also be injured in this case.

Treatment Complete flexion of the elbow with traction downwards of the forearm in the direction of the axis of the limb will often enable the surgeon to manipulate the fragment into position. If the arm is then fixed in front of the chest with the elbow fully flexed and the hand pronated and

resting under the chin, repair in good position may be obtained. A failure to secure complete reposition of the fragment will necessitate open operation and its fixation by wire, bone-peg, or screw

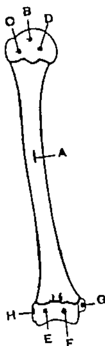


FIG. 14 19 CENTRES OF OSSIFICATION OF THE HUMERUS.

A, Shaft appears at eighth week of intra-uterine life B, centre for head in first year C, centre for great tuberosity in third year D centre for lesser tuberosity in fifth year B, C and D fuse in sixth year to form one epiphysis, which joins the shaft at twentieth year

E, Centre for capitellum in third year F, centre for trochlear surface in eleventh year G centre for medial condyle in fifth year H, centre for lateral condyle in twelfth year E, F and H coalesce about the fourteenth year and join the shaft at the seventeenth year G remains separate until the nineteenth year

Fractures of the Lower Epiphysis. Those involving complete or partial separation are very common in children. At birth and for some years afterwards the epiphysis consists of a single mass of cartilage (Fig. 14 19), including the two condyles as well as the articular surface, these are all involved in any separation together possibly with a fragment of the diaphysis.

As, however growth and ossification proceed the shaft encroaches rapidly upon the inner portion of the epiphysis, so that the epiphyseal line becomes almost rectangular the medial condyle being isolated from the rest of the epiphysis. As a result, this type of injury after the age of six or seven is placed at a somewhat higher level, and scarcely ever encroaches on the epiphyseal line It is usually transverse and runs through the olecranon fossa. The displacement is generally backwards, often with some amount of lateral displacement or deviation.

Treatment Reduction can usually be accomplished by flexion with some amount of traction. In young children, as in adults, it is best to avoid splints and merely keep the elbow in full flexion. Where there is much swelling from hæmorrhage, it may not be possible to gain complete flexion at once but as the swelling subsides it can be gradually increased Flexion is maintained

with the hand just below the chin for two or three weeks or until all local tenderness has disappeared Then the sling is relaxed so as to allow the hand to drop 3 inches (7 5 cm) and the after-course is as for the transverse supracondyloid fractures. Parents must however always be warned from the first that a perfect restoration of function cannot be guaranteed as the fossæ at the lower end of the humerus are encroached on and are liable to be filled up with bone and hence complete flexion or extension may be hindered Some amount of deformity also may persist and growth subsequently may be defective or irregular giving rise to cubitus varus or valgus

Dislocations of the Elbow Joint

These are common occurring particularly in young adults. The diagnosis is often difficult from the amount of swelling that quickly follows A careful investigation of the relative position of the bony points and of the degree of mobility of the different parts on each other is essential in order to arrive at a definite conclusion as to the exact nature of the lesion. In all cases a skiagram should be taken

Dislocation of Both Bones. This may occur either backwards, forwards, or laterally

(1) *Backward Dislocation* The backward variety (Fig. 14 15 A) is that most often seen The cause is a fall on the hand, as may be sustained when

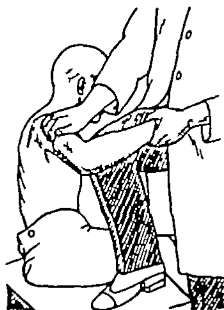


FIG 14 20. REDUCTION OF A BACKWARD DISLOCATION OF THE ELBOW

vaulting. If the coronoid process remains unbroken, it sometimes becomes locked in the olecranon fossa and renders the arm immobile if however it is detached, considerable mobility of both bones occurs, with crepitus. The forearm is semi flexed, the hand held midway between pronation and supination. The displaced bones form a considerable swelling at the back of the joint, above which is a marked hollow crossed by the triceps. The lower end of the humerus projects in front and the artery and the soft parts are displaced forwards. The measurement from the acromion process to the lateral epicondyle remains unaltered but that from the epicondyle to the

styloid process of the radius is distinctly shortened, and the distance betwee the epicondyles and the olecranon process is increased.

(2) *Forward Dislocation.* Dislocation forwards of both bones rarel occurs without fracture of the olecranon, although a few cases are on recor The displacement is readily detected, the forearm being lengthened perhaps t the extent of an inch The arm is in a condition of flexion, and, indeed, th accident can only take place from falling backwards on the point of th elbow when in this position. The triceps muscle will be considerably torr

(3) *Lateral Dislocation.* This is almost always incomplete, and ma accompany a posterior dislocation the bones may be displaced either in wards or outwards, the latter being the more common They are recognize by a careful examination of the relative position of the bony prominence and by radiography



FIG. 14 21 FRACTURE-DISLOCATION OF THE ELBOW JOINT
The medial epicondyle has been avulsed and pulled downwards by the flexor attachment.

Treatment Under an anæsthetic, the interlocked bony processes are unlocked. In the case of the posterior dislocation this is done by slight hyperextension followed by traction on the wrist. The elbow is then flexed while counter traction is made on the upper arm (Fig. 14.20) Care is taken to correct any lateral displacement at the same time and the accuracy of reduction is checked by radiography The arm is placed in a sling for two to three weeks and active movements then started

The dislocation may be complicated by fracture of the coronoid or medial epicondyle. Myositis ossificans or ossification of ligaments may limit movements. Lesions of the ulnar or median nerves or of the brachial artery may occur

Dislocation of the Radius alone. This may be either forwards, backwards or outwards.

Forward Dislocation This is the usual type and results from falls on the

hand when the forearm is in a state of extreme pronation or from forcible traction upon the hand or from direct injury applied to the back and outer side of the elbow The head of the radius rests against the lower end of the humerus in the hollow above the capitellum and the most characteristic feature consists in the inability of the patient to flex his forearm owing to the bone impinging against the lower end of the humerus It can be readily detected in this situation rotating with the movements of the forearm while a deep hollow is felt behind immediately below the external condyle. The forearm is somewhat flexed midway between pronation and supination the former act can be satisfactorily accomplished but supination cannot be carried further than halfway A marked fullness exists on the anterior aspect of the limb when the arm is extended Fracture of the upper third of the ulna sometimes accompanies this accident, especially when produced by direct violence (Monteggia fracture) The radius may be displaced forwards or backwards according to the direction of angulation in the ulna If this dislocation is not reduced great impairment of the mobility of the limb results, flexion beyond an obtuse angle becoming impossible

Reduction is accomplished by traction from the wrist with the forearm flexed to a right angle, combined with pressure over the head of the bone Owing to the fact that the orbicular ligament is ruptured the deformity is likely to recur unless the limb is immobilized in plaster with the elbow at right angles and with the forearm supinated. Angulation of the ulna must be corrected and stabilized preferably by internal fixation. The plaster must be retained for three to four weeks for the dislocation, or until union is complete in the case of the ulna fracture In old-standing cases excision of the head of the bone is desirable.

Subluxation of the Head of the Radius A common accident in children under four years of age consists in a downward subluxation of the radial head within the orbicular ligament, so that a fold of synovial membrane slips up and becomes nipped between the head and capitellum. It results from forcible traction of the hand, as from pulling up a child roughly after a fall and is a common nursery accident popularly known as *pulled elbow* The limb becomes fixed in a position of slight flexion with the hand pronated, the child crying out with pain. It is readily treated by completely flexing the limb subsequently extending and fully supinating it. This leaves no disability

Fractures of the Ulna

Fractured Olecranon. The olecranon process is frequently broken by direct violence, the patient falling on the bent elbow but occasionally by muscular action. The line of fracture usually runs through the base of the process at its attachment to the shaft and is generally transverse (Fig. 14 22). Should the tendinous and periosteal coverings of the bone remain intact, there is little separation but if the fracture is complete, the detached fragment is drawn up by the triceps and tilted backwards, while the bones of the forearm are subluxated forwards. Great swelling in and around the joint appears early On examination, the detached fragment can be readily distinguished and between it and the shaft a sulcus, which increases on flexing and diminishes on extending the forearm. If the fragments are not brought accurately into apposition, fibrous union occurs, and although the new cicatricial tissue may stretch considerably a useful elbow sometimes results.

In some cases the fragment is drawn up and fixed to the humerus, a false joint being developed below it. If however the fragments are brought in contact, bony union follows, even though some impairment of function may result from the formation of adhesions.

Treatment If there is no separation of the fragments the arm should be placed in a sling and the patient encouraged to perform active movements, as pain allows Where separation is present, in a healthy and vigorous patient, the fragments should be accurately approximated by open operation and fixed together by a screw (Fig. 14.23) or by a mattress suture of steel wire inserted through drill holes. In the elderly it is better not to operate, but to accept the fact that a fibrous union will occur and encourage early movement. In comminuted fractures, the fragments should be excised and the triceps tendon sutured to the ulna.



FIG 14 22. FRACTURE OF THE OLECRANON PROCESS WITH SEPARATION OF FRAGMENTS.



FIG 14 23 SCREW FIXATION OF FRACTURE OF THE OLECRANON. The screw should be oblique so that it engages the cortex of the bone.

Fractured Coronoid Process. This is so deeply placed and so well protected that fractures must necessarily be very uncommon, except as an accompaniment of dislocation of the ulna backwards. The signs relied on in making a diagnosis are that reduction of the dislocation is easier than usual, associated with crepitus, and that the deformity is likely to recur

Treatment This consists in apposing the bony surfaces, by complete flexion of the forearm.

Fractured Shaft. The shaft of the ulna is often fractured by itself as a result of direct violence, to which its exposed position renders it peculiarly liable. Fracture also occurs as an accompaniment of dislocation of the head of the radius (Monteggia fracture) The superficial position of the posterior border renders examination of the bone easy if displacement or a breach of substance occurs, it is readily detected, but when merely a fissure exists, it is not so easy to make out. The constant pain referred to one spot, the slight mobility and possibly crepitus, indicate the character of the lesion. No longitudinal displacement can occur if the radius remains intact, in such circumstances the only deformity consists in a slight drawing forwards

of the upper fragment by the brachialis muscle, while the lower fragment is approximated to the radius by the pronator quadratus.

Treatment The arm is placed midway between pronation and supination the deformity corrected and the limb kept at rest in a plaster cast.

Monteggia Fracture This is a fracture of the upper third of the ulnar shaft associated with a dislocation of the head of the radius (Fig. 14 24) The dislocation may be forwards or backwards depending on the angular deformity in the ulna Forward bowing of the ulna with an anterior dislocation is the usual type. Occasionally backward dislocation associated with a backward bowing of the ulna may occur The mechanism of the injury is that of a direct blow on the forearm. The fracture is often comminuted The elbow joint should always be included in a skiagram for fractures of the upper third of the forearm bones.

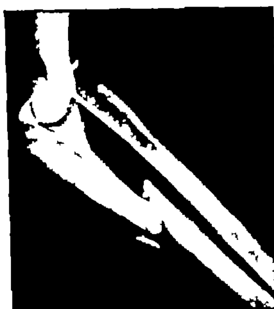


FIG. 14 24 A MONTEGGIA FRACTURE.
Fracture of the shaft of the ulna is accompanied by forward dislocation of the head of the radius.

Treatment It is important to reduce the dislocation of the radial head by direct pressure but this cannot be done until the bowing of the ulna is corrected The head of the radius may be stable when the forearm is fully supinated. If so a plaster extending from the axilla to the knuckles should be applied. If stability cannot be obtained it is best to stabilize the ulnar fragments by internal fixation either by a plate or medullary nail. It may be necessary to excise the radial head but this should *not* be done at the time of the injury or union may occur between the radial neck and the ulna. Excision should be delayed until the ulna is united The patient should be warned that a range of movement, short of normal is likely

Fractured Styloid Process. The styloid may be detached by direct violence or as a complication of fracture of the lower end of the radius (see Colles's fracture)

Fractures of the Radius

Fractured Head. The head of the radius may be broken alone, but this accident is often associated with other injuries to the elbow as, for instance, fracture of the lateral condyle, capitellum, or articular cartilage. The type of fracture may be a marginal fragment, vertical fissure or comminution may occur the displacement is slight if the orbicular ligament remains intact. In complete separation the head is immovable and crepitus is produced when the arm is rotated bony union usually follows, with more or less impairment of function, but sometimes the head, or a portion of it, remains detached as a loose body in the latter case the small fragment may get between the articular ends from time to time and lock the joint.



Fig. 14 25 Marginal Fracture of the Head of the Radius.



Fig 14 26. Complete Fracture of the Neck of the Radius.

Treatment If there is little displacement, or if manipulation results in a good reposition of the fragments, the arm is placed in a collar and cuff with full flexion of the joint for four weeks. When there is severe damage to the articular surface, the whole head of the bone should be excised.

Fractured Neck. This is usually a fracture of childhood and is " greenstick " in type. The head may be tilted and the deformity should be corrected either by manual manipulation or by open operation The head should not be excised in children owing to the likelihood of late deformity *i.e* cubitus valgus.

Fractured Shaft. The shaft is usually broken by direct violence more rarely by falls on the palm the latter accident, however rarely causes fracture except at the lower end. Greenstick fracture of the radial shaft is one of the common fractures of childhood Angular deformity is often marked (Fig. 14 27) Transverse fracture of the radius alone, or associated with a similar fracture of the ulna at about the same level is, in adults, the result of direct violence. Owing to tension in the interosseus membrane the fragments may approximate to one another and cross-union result, especially in infected fractures. Fractures of the lower one-third of the shaft are

common The small lower fragment may be displaced posteriorly and locked behind the main fragment

There is usually little difficulty in diagnosing a fractured radius the chief signs are localized pain and loss of power of active rotation while passive rotary movements are accompanied by crepitus the head of the bone and upper fragment remaining immobile below the outer condyle, unless impaction is present The displacement is characteristic If the fracture is situated *above the insertion of the pronator teres* the upper fragment is flexed and fully supinated by the action of the biceps and supinator muscles, while the lower fragment is drawn towards the ulna and fully pronated by the unopposed action of the two pronator muscles.

When the fracture is placed *below the insertion of the pronator teres* the upper fragment is drawn forwards by the action of the biceps, inwards by the pronator assuming a position midway between pronation and supination The lower fragment may be slightly approximated to the ulna by the direct action of the pronator quadratus the hand is pronated

Treatment In those situated above the insertion of the pronator teres muscle the fracture must be reduced and set up after reduction in a position of full supination. If this is not carried out perfect apposition of the bony ends cannot be obtained If the arm is pronated the pronators of the lower fragment relative to that of the upper is much greater the tendons of abductor pollicis longus and the extensor pollicis brevis are drawn taut and tend to squeeze the lower fragment towards the midline.

In fractures situated below the insertion of this muscle however the limb should be put up in a mid position Reduction can usually be effected by traction exerted on the forearm by an assistant pulling on the fingers and the thumb while counter-traction is maintained by a second assistant grasping the upper arm the surgeon manipulating the bones into position. A plaster slab is then applied to the extensor surface of the limb extending from the knuckles to the axilla The anterior aspect of the limb is padded with wool, and the plaster is then completed The plaster is kept on for a period of eight to ten weeks. Occasionally in spite of easy reduction, owing to the tearing of the ligaments of the inferior radio-ulnar joint, as soon as the traction has been removed the displacement recurs. In these cases one of two procedures may be employed An open operation may be advised with fixation of the fragments by a plate or Böhler's method may be employed This consists in passing a wire or pin, one through the olecranon process and another through the lower end of the radius and ulna. The fracture is then reduced in the usual way and the plaster applied to incorporate the projections of the wires. When the plaster has set and the traction is released the fragments cannot slip as they are maintained in position by the wires, the ends of which are embedded in the plaster

Fracture of the Lower Third of the Radius. This fracture is common in young people after falls in the football field or skating rink. The radial fracture is complete and the short lower fragment may be displaced behind the radial shaft (Fig. 14 27). There may also be a greenstick fracture of the neck of the ulna.

Treatment Manipulative reduction may be difficult and if it fails, the radial fragments should be hitched together through a short incision No internal fixation is necessary Plaster should be applied with the hand in slight palmar flexion or the short fragment may tilt backwards



FIG 14 27 FRACTURE OF THE LOWER THIRD OF THE SHAFT OF THE RADIUS.
The radio-ulnar joint is subluxated.

Colles's Fracture. The lower end of the radius is broken with extreme frequency constituting what is known as Colles's fracture. This injury occurs most commonly in women of advanced years, although it may happen at any age or to either sex. It is almost invariably due to falls upon the outstretched palm, when the hand is completely pronated and extended. The line of fracture is within 1 inch (2 5 cm.) of the wrist joint. It is usually transverse from side to side, but is oblique in an antero-posterior direction, sloping from above downwards and forwards, so that the fracture is nearer the wrist joint in front than it is behind (Fig. 14 28)

The *displacement* is somewhat complicated (*a*) The lower fragment is carried backwards and a little upwards, owing to the direction of the violence, *viz* a fall on the outstretched hand, the radius being compressed between the ground and the weight of the body and yielding at what is evidently a weak spot this deformity is maintained by the radial extensor muscles of the wrist and often by impaction of the fragments. (*b*) From the fact that the main violence is received on the thenar eminence, the outer side of the lower fragment is displaced more than the inner which remains fixed to the ulna by the strong inferior radio-ulnar ligaments. This position is in part kept up by the extensor of the thumb and the supinator muscle but mainly by impaction of the fragments The hand and carpus always *follow the lower fragments, hence the former is abducted, causing* the styloid process of the ulna to become unduly prominent and lower than that of the radius, whereas it is normally placed on a slightly higher level. In bad cases the styloid process of the ulna is actually torn off or the medial collateral ligament ruptured, allowing displacement outwards of the whole hand. (*c*) The lower fragment is also rotated around a transverse axis, so that the lower articular surface looks backwards as well as downwards, a displacement due to the fact that in falling the force is directed, through the carpus, more to the posterior than to the anterior aspect of the bone (*d*) The upper

fragment is pronated and approximated to the ulna by the pronator quadratus muscle

The *deformity* produced by the fracture is very characteristic. The hand is in a position of radial abduction usually pronated and with the fingers somewhat flexed Three abnormal osseous projections are present (*a*) The



A B

Fig. 14 28 Colles's Fracture.

A. Lateral View — Note backward tilt of lower fragment.

B. Antero-Posterior View — Note impaction. The styloid processes are on the same level.



Fig. 14 29 Colles's Fracture "Dinner-fork" Deformity

styloid process or head of the ulna is very marked owing to the radial abduction of the hand (*b*) on the back of the wrist is a prominence which terminates abruptly above, caused by the projection of the lower fragment ("dinner fork" deformity) and (*c*) corresponding to this dorsal projection there is a well-marked depression on the palmar surface and above it a less sharply defined swelling, which gradually shelves into the forearm due to

the upper fragment. Pronation and supination are lost and, as a rule, there is neither crepitus nor mobility owing to impaction of the fragments. An important diagnostic point is the relative position of the two styloid processes normally that of the radius is below that of the ulna, but in cases of Colles's fracture it is on a level with or above it.

The fracture is commonly impacted, the upper fragment being firmly driven into the cancellous tissue of the lower end excess of violence may however disimpact, but often at the expense of comminution of the lower fragment. Union is effected without difficulty but the patient should always be warned at an early date that some deformity may persist about the wrist, as well as some impairment in the subsequent mobility of the fingers and hand, owing to adhesions around the joints or tendon sheaths.

Treatment Early correction of the deformity is essential in every case. Even in elderly subjects correction should be undertaken. Anæsthesia must be sufficient to allow deliberate reduction of the fracture, for hardening of the plaster and for further manipulation should a skiagram reveal this to be necessary Should the general condition of the patient make the use of inhalation anæsthesia inadvisable, local analgesia gives excellent results, and is indeed preferred by many operators.

The skin is cleaned and painted with iodine. A fine needle is inserted at the level of the fracture line on the outer side. The piston is withdrawn and blood should flow into the syringe from the hæmatoma surrounding the fracture 5 ml. of 2 per cent. lignocaine solution is then injected slowly In the event of failure to withdraw blood two or three separate injections must be made at different sites. After ten minutes, complete analgesia and muscular relaxation should be obtained

Reduction is best effected by grasping the injured wrist between the two hands. One thenar eminence rests against the palmar aspect of the lower fragment, the other against the dorsal aspect of the radial shaft, just above the fracture. By firm pressure the deformity is increased by forcing the lower fragment backwards, thus disimpacting the fracture. A slight wriggle will aid the manœuvre.

The position of the thenar eminence of the operator is now changed that on the dorsal aspect making contact with the lower fragment, while that on the palmar side makes contact with the shaft. Firm pressure now causes reduction of the deformity and at the same time the patient's hand is carried into ulnar adduction.

The manipulation may be summed up thus increase deformity to disimpact, reduce, ulnar deviate. As Sir Robert Jones said "A firm grip with slight traction and twist of the wrist completely reduces the deformity It requires knack rather than strength."

The completion of the reduction is recognized by the restoration of the normal concavity on the anterior surface of the lower end of the radius and by the relative positions of the two styloid processes. The position of the fragments should always be checked by skiagrams taken in two planes after the splint has been applied

Splintage A splint should always be applied, even where the initial fracture has been merely a " crack " with no deformity

Care should be taken in applying the slab that the deformity does not recur although in the majority of cases this will not happen with gentle handling.

By far the most effective method of fixation is plaster of Paris A " slab is made from eight layers of bandage and of a length to extend from below the elbow to the knuckles. It is applied to the dorsal aspect of the forearm and hand either direct to the skin or over a single layer of stockinette It must be of such width that only the dorsal half of the limb is covered A 6-inch bandage is usually correct The hand is held in full ulnar deviation and slight palmar flexion until the slab has hardened A skiagram is then taken to check position and if this is good the palmar aspect of the limb is padded with wool and the plaster completed A rope of plaster is carried across the web of the thumb and the palm (Fig. 14 30)



A



B

FIG. 14 30 COLLES'S FRACTURE
Dorsal slab in use showing (A) ulnar deviation, and (B) slight palmar flexion.

After Treatment Active movements of the fingers, thumb elbow and shoulder must be encouraged from the outset. The splint should be retained for four or five weeks. The use of a sling should be discouraged

Smith's Fracture. A fracture of the lower end of the radius, known as Smith's fracture, is occasionally met with in which the displacement of the fragment is exactly the reverse to that seen in Colles's fracture, viz. the lower end of the radial shaft projects posteriorly whilst the lower fragment is displaced anteriorly More often the fracture line is oblique, running into the wrist joint which is subluxated Treatment is by traction on the hand followed by compression of the lower end of the bone. The wrist should be immobilized in slight dorsiflexion (Fig. 14 31)

Separation of the Lower Epiphysis. This injury occurs in young people, and when the epiphysis is displaced backwards, simulates somewhat closely a Colles's fracture (Fig. 14 32) The lower end of the diaphysis projects anteriorly to a much greater extent and indeed may protrude through the skin of the wrist. The lower end of the ulna may be involved in the accident, either the epiphysis being separated or the shaft broken a little above.

Treatment This is the same as for Colles's fracture Should arrest of growth result, the hand retains its connection with the stunted radius, but the ulna continues to grow downwards, and its lower end projects on the inner and posterior aspects of the carpus, which is pushed *en bloc* towards the radial side constituting Madelung's deformity (see p 215)



FIG. 14 31 SMITH'S FRACTURE.
In this type there is no dislocation of the wrist joint. The deformity is the reverse of that of Colles's fracture.



FIG. 14 32. DISPLACEMENT OF THE RADIAL EPIPHYSIS.

Fracture of both Bones of the Forearm

This injury may result from direct violence or falls on the palm. Any part of the bones may yield, but the middle and lower thirds are most frequently affected When due to direct violence, both bones may be broken at the same level but if due to a fall on the palm the radius usually gives way at a higher level than the ulna. The line of fracture may be transverse or oblique, and the displacement varies both with this and with the force employed The upper fragment of the radius lies in mid-pronation. There may be overlap and the fragments may be approximated due to tension in the interosseus membrane (Fig. 14 33)

Treatment It is most important to restore correct alignment in this fracture since failure to do so may involve serious impairment of forearm rotation. Under general or local anæsthesia, traction is applied with the forearm in supination or in the mid position according to the position of the upper radial fragment. When the bones are hitched together a padded plaster cylinder is applied from the axilla to the knuckles including the palm of the hand in order to control rotation. The plaster should be retained from eight to ten weeks.

If on relaxing extension there is a recurrence of the displacement, one of two procedures may be adopted Böhler's manœuvre, consists in passing a wire through the lower ends of the radius and ulna and another through the olecranon. After reduction in the way previously described the ends of

the wires are incorporated in a plaster cast and so prevent any alteration in the position of the bones Alternatively open operation and fixation of the fragments may be advised

The ulna is easily exposed by an incision along its posterior border but it is less easy to reach the radius without damaging the muscles. The incision should pass behind the brachioradialis, between it and the radial extensor tendons the origin of the extensor muscles of the thumb may have to be disturbed, but with care no permanent damage follows In the upper part the position of the posterior interosseous nerve must be remembered



FIG 14 33. FRACTURE OF BOTH THE BONES OF THE FOREARM.

The ends of the bones are freed and brought into position, and fixed by suitable means a plate to the radius is sometimes needed, but the ulna may usually be left without.

Injuries of the Carpus

Fractures may result from falls on the hand, or other violence, causing forced dorsiflexion of the wrist (*e g* a motor-car backfire). Occasionally the hand is forced into palmar flexion. Open fractures of the carpus are associated with crush injuries of the hand as may occur in a machine press.

Fractured Scaphoid. This is a common fracture. The signs are pain and swelling of the wrist, limitation of dorsiflexion, weak grip and tenderness in the " anatomical snuff-box " or over the tuberosity of the scaphoid at the base of the thenar eminence.

Any injury to the wrist of more than minimal severity should be radiographed to exclude the possibility of injury to the scaphoid bone. Views must be taken in three planes, antero-posterior lateral and oblique. Many injuries are treated as sprains which in point of fact are undoubtedly fractures of the scaphoid inefficient treatment spells a lifetime of pain and limitation of movement in the wrist joint. The blood-supply of the scaphoid bone is by means of two vessels, one entering the tuberosity and the other the middle of the bone. A fracture through the waist of the bone may damage the blood supply to the proximal portion. Avascular necrosis will occur If the wrist is efficiently immobilized for a period of from three to six months, re vascularization may take place, but the sequel will almost inevitably be osteoarthritis, with restriction of movement, pain and an impaired grip

A skiagram may reveal a crack in the scaphoid at first only recognizable with a lens, but a further skiagram taken in two or three weeks will show an



Fig. 14 34 Recent Fracture of the Scaphoid Bone.



Fig. 14 35. Longstanding Fracture of the Scaphoid Bone.

obvious fracture This is due to decalcification at the fracture site (Fig. 14 34). Confusion may very occasionally be caused by the scaphoid bone being bi-partite.

Treatment *This consists in complete immobilization of the wrist by a* plaster extending from the knuckles to high up in the forearm, immobilization being maintained until union of the fragments is completed, a process which will take some twelve weeks or more. The plaster should immobilize the first metacarpophalangeal joint.

Established non union is indicated by sclerosis of bone on each side of the fracture line (Fig. 14 35) Before union can take place, the sclerosed bone must be broken up by drilling under radiographic control The wrist is then immobilized until union occurs. Occasionally the fracture line may be bridged by a thin bone graft, but this is usually unnecessary

The presence of " cysts " in the bone indicates delay in union but not necessarily *non-union and these* bones will sometimes unite after immobilization for six to nine months.

Fractured Triquetrum. A small flake of bone may be avulsed from the dorsal surface This may be regarded as a "sprain fracture"

Treatment The wrist should be immobilized by plaster of Paris in dorsiflexion for three to four weeks

Dislocations at the Wrist Joint

These occur as a result of forced dorsiflexion of the hand either by falls, backfires or in airplane or car crashes The injury is relatively uncommon The carpal bones may be displaced singly or in almost any combination The two most usual types are described

Perilunar Dislocation. This may occur as a pure backward dislocation of the whole carpus, leaving the lunate bone in its normal relation to the radius (Fig 14 36) The trans scaphoperilunar dislocation is a variant in



FIG. 14 36 PERILUNAR DISLOCATION OF THE CARPUS.



FIG. 14 37 DISLOCATION OF THE LUNATE BONE.

which the scaphoid is fractured through its waist. Half the bone remains in contact with the lunate the other half is displaced backwards with the rest of the carpal bones.

Diagnosis Unless seen very soon after the accident the fact that there is backward displacement will be obscured by much swelling. Finger and wrist movements will be limited It will be obvious that the wrist is severely injured but the actual type can only be decided by careful study of skiagrams in comparison with those of the normal wrist. Associated flake fractures, avulsed by ligaments, together with fractures of the styloid processes of radius and ulna may complicate the picture

Treatment The best results are obtained by early manipulative reduction. This may however be attempted up to two weeks after the injury

Manual traction is made on the hand an assistant making counter traction on the elbow The pull is kept up steadily for several minutes and then the wrist is gradually flexed. Fixation should be in moderate palmar flexion, for three weeks by a dorsal plaster slab Reduction must be checked by radiography After three weeks active movements may be allowed unless there is also a fracture of the scaphoid In this case, the wrist is gently brought up into dorsiflexion and immobilized in plaster for three months.



Fig 14 38 Oblique Fracture of the Shaft of the Fourth Metacarpal



Fig 14 39 Fracture of the Neck of the Fifth Metacarpal



Fig. 14 40 Bennett's Fracture of the Base of the First Metacarpal



Fig. 14 41 Bennett's Fracture Dislocation

(2) *Fracture-Dislocation* The fracture line is oblique into the joint between the metacarpal and the trapezium A triangular fragment remains in position but the shaft dislocates outwards and becomes prominent beneath the skin (Fig. 14 41). This fracture is easy to reduce but is unstable.

Treatment Reduction is effected by traction on the thumb together with pressure over the base of the metacarpal. There are two methods of control

(*a*) By continuous traction in plaster This can be carried out by strapping extension applied to the thumb tied to a wire hoop incorporated in the plaster

(*b*) Internal fixation by a screw or nail. This method is to be preferred.

Dislocation of the First Metacarpal. This is an unusual injury the force being sufficient as a rule to produce a fracture as well (Fig. 14 42) Reduction is simple and a plaster should be applied.



FIG 14 42. DISLOCATION OF THE FIRST CARPO-METACARPAL JOINT

Injuries of the Fingers

Fractures or dislocations of the fingers may be accompanied by severe damage to the soft tissues. Thus, the ligaments, tendon sheaths or tendons may be injured and impairment of function may result from this damage, rather than from the actual fracture. An apparently trivial injury judged by the skiagram, may lead to permanent disability in the injured finger or in the whole hand. Much disability can be avoided by correct treatment.

The important points to remember in the treatment of the finger injuries are

(1) Early recognition and reduction of displacement of fractures and dislocations.

(2) Splinting must be kept to a minimum consistent with efficient immobilization of the injured part. The whole hand should not be splinted for an injury of one finger Fingers stiffen easily and the uninjured fingers must be kept mobile by active exercises from the start.

(3) Prolonged splinting is to be avoided. Most fractures are sufficiently stable for the splints to be removed and for guarded movement to be undertaken in three or four weeks.

(4) *Fingers should be splinted in flexion and never straight. A stiff straight finger is useless, a stiff flexed finger is of some use for gripping provided there is movement at the metacarpo-phalangeal joint.*

(5) Each finger flexes *towards the base of the thenar eminence* and not in line with its metacarpal bone. When splinted in flexion this point must be remembered.

(6) *Open fractures and dislocations must be treated on general principles.* Immediate wound toilet and skin closure is essential if good function is to be obtained

(7) Severely injured fingers are better amputated so that function can be restored in the others.

(8) The thumb should never be amputated as a primary procedure. It is the most important digit in the hand. Even when severely injured much tissue may be viable and the preservation of all such tissue is essential to the reconstructive surgery which may eventually be necessary.

(9) Œdema of the hand may lead to stiffness. The severely injured hand must be treated by elevation with the patient in bed if necessary. Movements of the fingers and thumb must be started as early as possible.

Fractures of the Phalanges

These may be either fractures of the shaft or fractures with joint injuries.

Shaft Fractures. These are commonly of the proximal phalanx (Fig 14.43). The fracture tends to bow forwards due to the pull of the interosseus muscles.



Fig. 14.43. Fracture of the Proximal Phalanx of the Thumb.



Fig. 14.44. Two Fractures are shown. A, Sprain Fracture of the Base of the Proximal Phalanx of the Thumb. B, Fracture of the Base of the Terminal Phalanx, involving the Joint.

Treatment. The deformity is corrected by semiflexing the finger. The position is maintained by a splint of malleable metal or plaster extending from the base of the metacarpal to the tip of the finger. This may be applied on the palmar or dorsal aspects. When traction is considered necessary the splint should be on the palmar aspect and continuous with a forearm plaster. A wire hoop is incorporated so that traction can be made by a rubber band connected to a Brock's pin inserted through the pulp of the finger.

Crush Fracture of the Terminal Phalanx. This is a very common injury. It results from accidents such as a blow from a hammer, a window falling or the finger being caught in a closing door. The pulp of the finger is crushed and may be lost and a subungual hæmatoma forms with subsequent shedding of the nail.

Treatment. The pain of a subungual hæmatoma can be relieved by the release of tension. This is best done by boring a small hole through the nail by means of a red hot needle or the end of a wire paper fastener. The procedure is painless.

Loss of pulp should be treated by full thickness skin grafting, obtained either from the abdominal wall, or from the thenar eminence

The fracture itself rarely gives trouble unless it becomes infected. No splinting is required other than protection of the healing area by some gauze soaked in collodion

Fractures with Joint Injuries. Lateral strains applied to the fingers may cause rupture of the ligaments but often a small fragment of bone is avulsed from the joint margin (sprain fracture, Fig. 14 44 A) If these fragments are rotated or much displaced, they should be removed otherwise the injury is treated as a sprain by elastic strapping applied to support the joint and by active movements The patient must be warned that the joint will remain swollen and that movement will be limited for many months For persistent pain, an arthrodesis of the joint may be necessary

In a mallet finger avulsion of a flake of bone from the distal phalanx may occur instead of rupture of the extensor tendon.

Dislocations of the Fingers and Thumb

First Metacarpo-phalangeal Joint. This is a backward dislocation of the proximal phalanx, from a hyperextension injury (Figs. 14 45 and 46)



Fig 14 45 Dislocation of the First Metacarpo-phalangeal Joint



Fig. 14 46. Skiagram of Dislocated Thumb.

The metacarpal head protrudes between the two heads of the flexor pollicis brevis muscle which are joined by a transverse fibrous band. This band becomes hitched behind the metacarpal neck and makes manipulative reduction difficult or impossible, unless it is ruptured or divided Division is easily accomplished by a tenotome inserted in the mid-line immediately proximal to the base of the phalanx After reduction, the joint is stabilized by a figure of eight strapping.

Dislocation of the Fingers. The interphalangeal joints may be dislocated by blows on the fingers as may happen when catching a cricket ball. Reduc

tion is easy when the diagnosis is made within the first few days If attempted later reduction may be difficult or the joint may be unstable with recurrence of the deformity

Stable reductions require no splinting and early movements should be started When unstable a splint should be applied for two weeks The patient should be warned that some deformity or stiffness may persist and that pain may call for an arthrodesis of the joint.

a spot well above the junction of the fixed base and the movable upper part, a point where the effect of jars and wrenches is mainly felt. (e) Nature has, moreover introduced a whole series of buffers and other means of preventing shock to the spine when a person falls on his feet, e g the arches and elasticity of the foot, the changes in direction of the bones at each joint, the inter articular cartilages of the knee, etc.

The parts of the spine most exposed to injury are those where a fixed and movable portion meet, e.g the dorsilumbar and the cervicodorsal regions. In addition, the upper part of the dorsal curve, which projects backwards, is relatively a weak spot, and fractures are not at all uncommon about the fourth dorsal vertebra. The weight of the head explains the frequency of lesions about the upper cervical regions.

Sprains of the Spine. These are very common accidents, a fact not to be wondered at when its complicated muscular and ligamentous arrangements are considered. They are produced by any sudden or unexpected move ments, such as falls, especially from horseback, railway or motor accidents. The injury affects most frequently mobile parts of the spine e.g the cervical and lumbar regions, and may be limited to either ligamentous or muscular structures, or may involve both.

Signs The physical signs are those of a severe but localized trauma, viz pain, tenderness and perhaps a little swelling or bruising the subjective phenomena are much increased by movement, so that the spine is kept rigid. If only the posterior muscles or interspinous ligaments are involved, pain is elicited by flexion of the spine, as it puts these structures on the stretch active extension is also painful, but passive backward extension is painless. Similarly unilateral lesions are productive of pain on stretching the injured structures. If the trouble is limited to the external muscles and ligaments, no further consequences are likely to arise but when the ligamenta subflava are lacerated and the spinal canal is opened, pressure symptoms may arise from blood finding its way into the canal outside the dura mater

In the *cervical* region sprains may occur as a result of severe blows on the head, causing rupture of the ligaments. The head and neck are held immovable and rigid and there is often considerable loss of power the patient being sometimes unable to lift the head spontaneously from the pillow Sprains in the *lumbar* region are very common, both as a consequence of overlifting and as a result of road injuries, when they are often associated with neurological symptoms. The back is kept fixed and rigid, the patient being unable to turn or stoop without pain. Sometimes hæmaturia results from injuries in the lumbar region, arising from an associated contusion of the kidneys. It should be remembered, however that when claims for compensation are pending, the signs and symptoms may occasionally be exaggerated

Treatment The patient should be kept at rest and heat applied to the injured part. When the painful or inflammatory symptoms have disappeared, massage and exercises are given. In the severer cases the individual should be kept in bed if the injury is in the cervical region some form of mechanical support may subsequently be necessary The onset of paraplegia would raise the question of laminectomy

Penetrating Wounds of the Spine. These are fortunately uncommon in civil practice, being generally due to stabs with pointed instruments such as bayonets, or to gunshot wounds. They occasionally result from falls, the un-

fortunate individual becoming impaled on area railings, branches of trees etc.

Symptoms These may be grouped as (*a*) those due to the wound in the soft parts, which may also involve the peritoneal and pleural cavities, or damage to some of the viscera in the neck, the vertebral artery is exposed to injury from this type of accident, leading to serious hæmorrhage (*b*) various forms of fracture the cord being compressed by fragments of bone which have been driven inwards, or by extravasated blood (*c*) those due to laying open the spinal membranes with loss of cerebrospinal fluid or to delayed meningitis and (*d*) those due to wounds of the spinal cord The effects of spinal lesions at different levels are given in Chapter 25 The cord may escape entirely nerve roots or trunks only being involved and in the lumbar or sacral regions the damage will be limited to the cauda equina

Treatment Thoroughly exploring the wound under an anæsthetic, removing foreign bodies or displaced fragments of bone and attempting to render it aseptic is necessary Wounds of the vertebral artery or other structures are dealt with on general principles, and special attention is naturally given to the cord and its membranes. Should the dura have been opened and the cord escaped injury an attempt may be made to close the wound in the meninges. The patient should subsequently be kept in the prone position with the head low so as to prevent, as far as possible, the escape of cerebrospinal fluid. If the cord itself is divided or lacerated it is useless trying to unite it, since its function is inevitably destroyed Where however the cauda equina has been injured, it is justifiable to open the spinal canal to a sufficient extent to expose the divided nerve trunks, and to suture them.

Fractures of the Spine

The spine may be fractured as a result of (*a*) direct (*b*) indirect violence

Fractures by Direct Violence With the exception of gunshot wounds, these injuries are not very common. They may result from direct blows on the spine as might occur from a heavy stone or swinging baulk of timber or from falls on to the back across some projection such as an iron railing. Any part of the vertebral column may be involved Penetrating wounds, together with the fracture which is necessarily open are likely to be infected

Fractures by Indirect Violence These are the more usual injuries of civilian life. Three types of force may be responsible (*a*) Acute flexion of the spine, a very common accident (*b*) Hyperextension which is rare, and (*c*) Avulsion of a process by muscle pull.

Injuries to Soft Tissues. It is important to think of spinal injuries not only in terms of fracture of bone, but also of soft tissue damage. This point was stressed in connection with injuries to the limbs and in the spine it assumes an even greater importance. In addition to tearing of ligaments and muscles, two structures of great importance may be concerned in the injury namely the spinal cord and its nerve roots, and the intervertebral discs.

The complication of spinal cord injury may dominate the clinical picture so much that the importance of the fracture itself pales into insignificance.

Classification of Fractures of the Spine

It is convenient to classify injuries of the bones of the vertebral column into (*a*) injuries of the accessory processes, and (*b*) injuries of the vertebral bodies.

Injuries of the Accessory Processes

Fracture of a Transverse Process. This occurs in the lumbar spine and is a fairly common accident in labourers who fall unexpectedly into the trench which they have dug. One or more transverse processes are avulsed by sudden contraction of the quadratus lumborum muscle. The symptoms are always more severe than the appearance of the skiagram would suggest, due to the fact that the injury is mainly to the muscle and its fascia. There is local tenderness, muscular rigidity and later considerable bruising may be seen

Treatment This should be guided by the symptoms and not by the skiagram. Complete bed rest on a firm mattress, or the application of an ambulatory plaster jacket may be required, until all pain has subsided. Restoration of strength and mobility must be secured by graduated exercises, while in the jacket and subsequently The period of disability may be as long as eight weeks.

Fracture of a Spinous Process. This is a rare injury In the lower cervical and upper thoracic region, the process may be fractured by direct violence as when pushing in a rugger scrum, or by muscle violence, a type which has been described in clay shovellers and known as "Shoveller's" fracture.

Fracture of the Laminæ. This is always due to direct violence. When both laminæ are broken the central portion carrying the spinous process is liable to be depressed with resulting compression of the spinal cord.

Fracture of an Articular Process. *This is seldom a solitary injury and is* more often encountered in connection with fracture-dislocations of the spine The close proximity of the articular processes to the nerve roots should be remembered.

Injuries of the Vertebral Bodies

These are nearly all flexion injuries. There are three types (*a*) Wedge fractures (60 per cent.) (*b*) Comminuted fractures (10 per cent.) (*c*) Fracture-dislocations (20 per cent.) Marginal fractures account for the *remainder*

Wedge Fracture. This is a very common injury and usually occurs in the mid thoracic and thoraco-lumbar regions (Fig. 15 3). The force may be moderate in degree, a heavy fall from a chair on *to the buttocks* being sufficient. Mid thoracic wedge fractures sometimes follow electroconvulsive therapy Several vertebræ may be fractured. In the middle-aged or elderly patient, in whom the force has been trivial, the question of malignant disease must be borne in mind, while in senile osteoporosis of the vertebræ, wedge fractures are common.

Diagnosis Following an injury there is pain in the back, aggravated by movement, together with local tenderness on pressure over the spinous process. Symptoms are often surprisingly slight. The presence of a fracture may be missed in the skiagram and only later when traumatic osteoporosis allows *further* collapse *of* the vertebra to take place is the condition recognized This condition has been called "*Kümmell's disease* but it is probable that this does not constitute an entity and does not occur apart from the sequence of events described. *The presence of a retroperitoneal* hæmatoma in front of the vertebral bodies, may induce abdominal pain and a rigid abdominal wall, simulating an "acute abdomen." When such symptoms

and signs present after injury, the possibility of vertebral fracture should be considered as well as that of a ruptured viscus

Complications Paraplegia is uncommon after wedge fractures and when it does occur is usually transient Persistent backache may be due to degenerative changes in the intervertebral discs or in the posterior *articulations.*

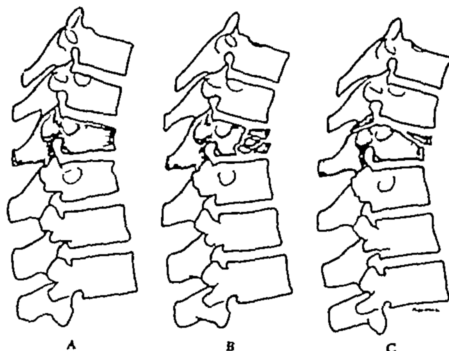


FIG. 15 2. THREE TYPES OF FRACTURE OF THE SPINE DUE TO FLEXION.
A. Simple wedge fracture.
B. Comminuted fracture produced by acute angulation.
C. Fracture-dislocation.

(*After Watson-Jones.*)





A B

FIG 15 3 WEDGE FRACTURE OF A THORACIC VERTEBRA.
A. Lateral view B. Antero-posterior view

First Aid Patients, in whom a fracture of the spine is suspected should be moved as little as possible. On no account should they be sat up or carried with the spine in a flexed position as happens when a patient is carried in a blanket, lying on his back. Some form of rigid stretcher should be used, the traditional door gate or hurdle being excellent for the purpose. Shock should be treated by a warm covering, and pain by morphine

Treatment The treatment of these fractures has undergone considerable modification in recent years Past teaching has concentrated upon reduction by hyperextension, followed by immobilization in a plaster jacket for about three months. The method of application described by Watson-Jones is as follows The patient is given one third of a grain (20 mg.) of morphine half an hour before the plaster jacket is applied. Then two tables are arranged end to end with a considerable space between them. The front table is then raised on blocks so that it is some two feet higher than the other The patient is carefully lifted face downwards on to the lower table and a double layer of stockinet is pulled over the trunk and fixed over the shoulders and

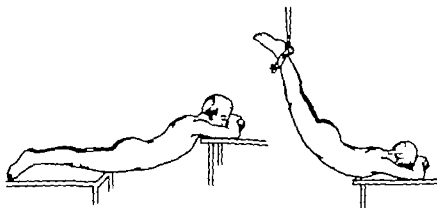


FIG 15 4 TWO METHODS OF PRODUCING HYPEREXTENSION OF THE SPINE.

beneath the perineum by means of a few stitches. The bony prominences, *i e* spinous processes and iliac crests, should be protected by pads of sorbo sponge By means of two assistants the patient is now assisted into such a position that he is gripping the edge of the higher table with his abducted arms, while the lower table supports his lower limbs. A few moments pause will allow the spine to hyperextend as much as possible before application of the plaster of Paris bandages. The jacket must extend from the suprasternal notch to the symphysis pubis and be well moulded over the iliac crests (Fig. 15 6) When dry the patient is turned on to his back with a pillow supporting the lumbar region and the plaster trimmed. The patient is allowed up in about ten days and should be in the jacket for three to four months. During this time daily extension exercises are carried out.

In many cases excellent radiographic reduction is achieved, but this is not necessarily followed by excellent functional recovery Recent trends are towards symptomatic treatment only for the simple wedge fracture.

There is no attempt at reduction, the patient is put to bed on a firm mattress with a pillow in the hollow of his back. He is turned daily on to his face for extension exercises and is allowed to sit in a chair when pain has gone, probably in three to four weeks. Exercises must be continued until there is

good power in the spinal muscles and he should be able to return to light work in two to three months.

Comminuted Fracture This again is a flexion injury but here the force is greater The vertebral body is comminuted by the body above it. When seen in a lateral skiagram the antero-posterior diameter of the bone is increased (Fig. 15 5) Portions of bone may be forced forwards or backwards into the spinal canal causing injury to the spinal cord or nerve roots. The intervertebral discs may be ruptured

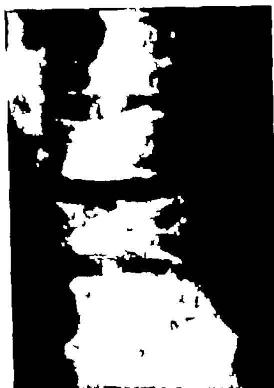


FIG. 15 5 COMMINUTED FRACTURE OF A LUMBAR VERTEBRA.
A portion of the body has been displaced backwards into the vertebral canal. When this occurs, the spine must not be hyperextended.

Treatment The spine is more unstable than with a wedge fracture and the period of rest must therefore be longer (*a*) When the *spinal canal is intact* the patient may be nursed on his back with the spine hyperextended by a pillow or by sandbags placed beneath the mattress but because of the instability a plaster jacket may be advisable. (*b*) When the *spinal cord is damaged* a plaster jacket is applied, without hyperextension, the patient standing, with head traction.

Fractures in the upper or mid-thoracic region cannot be reduced by this method, nor can they be effectively immobilized in a plaster jacket. These patients should be nursed in bed until symptom free

Fracture-Dislocations

These injuries result from direct or indirect violence. A direct blow on the back may act as a shearing force, but the main injury is one of acute

flexion Such injuries occur from roof falls in coal mines, or from heavy objects dropped on to the already flexed back.

The continuity of the spine is disrupted by a dislocation between the vertebral bodies together with wedging or comminution of the bones There is also a dislocation of the posterior articulations or a fracture of the articular processes or some part of the neural arch. The lesion is unstable and there is usually gross damage to the spinal cord or nerve roots. The skeletal injury is therefore overshadowed by paraplegia which is likely to be permanent (Figs. 15 7 and 8)

These injuries occur most often in the cervical and upper thoracic region of the spine. This fact is explained by the anatomy of the articular processes which are more horizontal than in the lumbar spine The lumbar articular



FIG. 15 6. PLASTER JACKET FOR FRACTURE OF THE SPINE

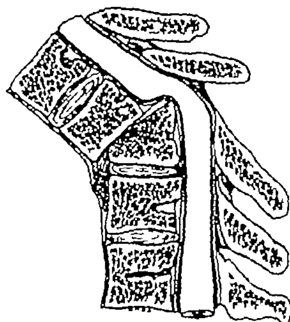


FIG 15 7 COMPLETE FRACTURE-DISLOCATION OF THE SPINE IN THE LOWER THORACIC REGION, WITH DISPLACEMENT AND COMPRESSION OF THE CORD.

processes are strongly built and placed vertically so that dislocation is difficult and fracture rare in this situation.

An unusual form of fracture-dislocation in the lumbar region may occur after great violence, in which the articular processes become locked. Reduction cannot be achieved except by open operation to remove the lower articular processes of the locked pair Lesions of the cauda equina are likely in this injury

Physical Signs The signs are usually very evident, consisting of local pain swelling and bruising and a certain amount of angular deformity although the latter often disappears when the patient is laid flat on his back for transport to his home or to the hospital. All unnecessary movement should be avoided for fear of adding to the injury of the cord. Paraplegia below the part injured is present in most cases and shock is considerable. When the cord is crushed there is complete flaccid paralysis of the parts below the lesion, together with anæsthesia, and a fatal issue can occur at

an early date due to toxæmia from cystitis or infected bed sores Lesions of the cervico-thoracic region in which the cord is extensively damaged quickly become dangerous to life in that they cause paralysis of the muscles of respiration with the exception of the diaphragm predisposing to pneumonia. Complete lesions at or above the level of the fourth cervical segment are usually fatal at once from involvement of both phrenic nerves. The general mortality of fracture-dislocations of the spine is about 70 per cent. The special phenomena of paraplegia at different levels are dealt with in Chapter 25

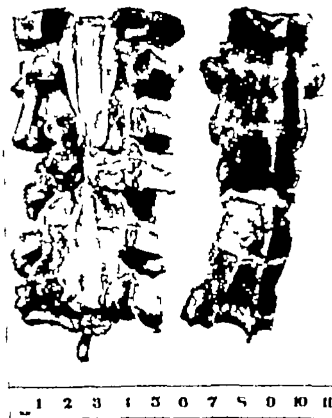


FIG 15 8. CRUSHING OF THE CORD IN A SEVERE FRACTURE-DISLOCATION IN THE CERVICAL REGION. (*King's College Hospital Museum.*)

Prognosis This turns largely on the site of the injury the amount of damage sustained by the cord and the facilities for treatment. The higher the lesion, the greater the danger although patients with paraplegia from cervical fracture may live for years and even partially recover if the cord has not been totally destroyed.

Treatment of Fracture-Dislocations without Cord Involvement. These are reduced by careful extension and then treated as for the unstable comminuted fracture by a plaster jacket. The one exception is that when there is locking of the dislocated facets, extension must not be applied until they are disengaged either by traction or at open operation.

Treatment of Fracture-Dislocations with Cord Involvement. The patient is carefully placed on a prepared bed, the greatest gentleness being used in handling and lifting him, for fear of increasing the damage to the cord. The bed must have a firm basis on fracture boards on which is placed a divided mattress made preferably of sorbo-rubber This should be from 12 to 18 inches thick. Failing this, a box spring mattress may serve.

Shock is treated. A complete neurological examination should be made at the earliest possible moment, preferably by a neurologist, so that a record is available against which subsequent recovery or deterioration may be checked. Good skiagrams are essential.

It is well to remember that cord damage is irreversible but that root damage may recover Furthermore the damage occurs at the time of the accident so that reduction of the dislocation may make little or no difference to the prognosis of the case.

Bearing these facts in mind the treatment should be directed to the following items shock, nursing care, the bladder and finally the fracture dislocation, in that order

Nursing Care The chief difficulty is the prevention of bed sores. The patient is turned two-hourly both by day and by night, first lying on his back, then one side, then on the other Great care is taken to avoid burns by hot water bottles which should never be placed in the bed of a paraplegic patient. At each turning the pressure points, heels, trochanters, sacrum and buttocks, are washed with a good quality soap and water the skin stimulated by friction, and the parts carefully dried. The application of olive oil is beneficial.

In order to prevent pain and further damage to the nerve roots, the patient must be rolled gently as a whole, so that rotation in the spine is avoided. This presents difficulties during the first three or four weeks and the patient needs to be heavily sedated during this period. After about four weeks the spine becomes sufficiently stabilized by fibrous tissue to enable turning to be carried out more readily and with less discomfort.

Although the above method is advocated by some authorities, others feel that the spine should be stabilized from the onset, to enable routine nursing to be carried out more easily

Open Fixation. The spinous process and laminæ are exposed at the site of the lesion and this may be an opportunity to explore the damaged nerve roots. The stabilization is effected by a single or double metal plate bolted to the spinous processes for two segments above and below the lesion. These will hold the fracture during the early stages of treatment.

A disadvantage is that an operative procedure has to be carried out upon a severely injured patient in whom healing may be slow and in whom infection of the wound would be a catastrophe.

The Bladder Retention of urine is treated by daily or twice daily catheterization under very strict aseptic precautions, which should include the wearing of a mask and gloves, careful cleaning of the meatus and sterile towelling. If care is taken, urinary infection may be avoided but it is wise to administer antibiotics as an added precaution. When facilities for aseptic catheterization are not immediately available, the bladder should be allowed to distend and the urine can be allowed to trickle away into a sterile container or the bladder may be emptied by periodical manual compression.

The bowels will need attention after a few days and are best treated by

rectal washouts as and when necessary When death occurs it is from respiratory paralysis, urinary infection or toxic absorption from infected sores.

The treatment of paraplegia and retention of urine is discussed in more detail in Chapter 25

The Fracture-Dislocation When the paraplegia is complete and permanent, there is no point in reducing the deformity In partial paraplegia, however the lesion is reduced gently by hyperextension over a pillow or sandbag placed under the mattress. Plaster jackets and plaster beds should not be used in paraplegic patients owing to the danger of pressure sores

Injuries of the Cervical Spine

Hyperflexion or hyperextension may be responsible for such injuries. It is well to remember the possibility of an injury to the cervical spine in any



FIG. 15 9 AN UNREDUCED DISLOCATION OF THE THIRD CERVICAL VERTEBRA.
A late case in which reduction failed and in which stability was obtained by means of a bone graft. There were no symptoms of cord involvement.

patient who has sustained a head injury severe enough to produce concussion.

Flexion Injuries Dislocations. The neck is the only region of the spine in which a pure dislocation can occur and this is due to arrangement of the articular facets. The dislocation may be unilateral or bilateral (Fig. 15 9).

Unilateral dislocation is likely when the head is rotated as well as flexed. It occurs commonly between the fifth and sixth cervical vertebræ but any level may be affected. The upper articular process slips forwards on the lower and locks in this position so that the head is turned to the opposite side. The cord escapes injury but the spinal nerves may be compressed or stretched with the result that pain and tingling is felt throughout its peripheral distribution.

The diagnosis may be difficult unless good quality skiagrams are available. Stereoscopic views are helpful.

Treatment Gentle traction under general anæsthesia, combined with lateral head bending is usually successful. If it fails, continuous skeletal traction should be employed, as explained below The reduction is stable, but immobilization of the neck in a cervical collar is advisable for a few weeks.

Bilateral Dislocations and Fracture-Dislocations. With these injuries, cord damage is likely but not inevitable. Dislocation may be complicated by a fracture of the articular processes, or a compression fracture of the vertebral body

Treatment If there is no paraplegia the treatment of choice for bilateral dislocations and fracture-dislocations is skeletal traction applied to the skull This may be done in two ways (*a*) by skull calipers (Fig. 15.10), and (*b*) by zygoma traction made by small metal hooks inserted beneath the

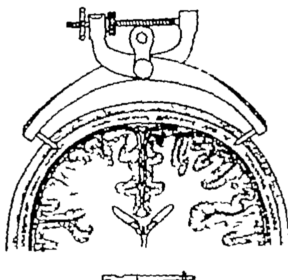


FIG. 15 10. SKULL CALIPERS APPLIED TO THE SKULL.
Two small burr holes are made with a drill which pierces the outer table only (The flanged drill is seen at the bottom of the picture.)

zygomatic arch on each side. This method is easy to apply and safe, but is a source of some discomfort to the patient.

The patient lies supine and the weight increased gradually up to a maximum of about 25 lb (Fig. 25 6) Daily skiagrams are taken, until reduction is achieved. Two methods of procedure are then available (*a*) A Minerva plaster is applied before the traction is released This consists in a spinal jacket with an extension of the plaster to include the neck and the head (Fig. 17.44) Immobilization should be for three months. (*b*) A posterior spinal fusion is carried out before application of the plaster This is desirable in nearly every case because even after fixation for three months the spine may be unstable and the dislocation recur

Fractures of Special Vertebræ. *The Odontoid Process* Fracture of this process of the axis or dislocation by rupture of the transverse ligament of the atlas may cause sudden death. One of these injuries is usually found at autopsies in cases of judicial hanging.

The Atlas Fractures are so rare as to need no mention here

Hyperextension Injuries. Paraplegia is sometimes due to hyperextension of the cervical spine. The accident may be a fall downstairs in which case the patient may be concussed and a bruise may be visible on the forehead A similar accident can occur for instance when a bather is struck by a large wave and rolled over backwards. Radiological examination of the neck may show nothing abnormal but at autopsy the anterior common ligament is found to be ruptured so that the vertebral bodies may easily be separated by hyperextension When this happens the cord is stretched and the cause of the paraplegia is apparent

In a paraplegic patient great care must be exercised when taking skia grams of the cervical spine for if the head is allowed to fall back, sudden death may occur

THE PELVIS

Fractures of the pelvic bones are almost always the result of direct injury such as falls, blows, gunshot wounds or crushes in motor or aeroplane accidents. For convenience they may be described under a number of headings.

Fracture of the False Pelvis. A portion of the iliac crest may be broken off the anterior superior spine separated or merely a fissure in the bone produced The displacement is rarely great. Considerable pain is always present, especially on any vigorous respiratory movements, but crepitus is rarely detected Union occurs readily if the patient is kept quiet in bed with the shoulders raised and the legs supported to relax the abdominal muscles. A pelvic binder gives comfort.

Septic penetrating wounds, such as those following gunshot injuries, are liable to result in a subacute spreading osteomyelitis which is most trouble some. An abscess may form on the inner aspect communicating with the exterior by a narrow passage in the bone made by the penetrating body

Fracture of the True Pelvis. This is a more serious accident. The pelvic ring is interrupted. When the fracture occurs at one place the stability of the



FIG 15 11 FRACTURE OF THE PELVIS THROUGH THE RAMI OF BOTH PUBES.

The diagnosis may be difficult unless good quality skiagrams are available. Stereoscopic views are helpful.

Treatment Gentle traction under general anæsthesia, combined with lateral head bending is usually successful. If it fails, continuous skeletal traction should be employed, as explained below The reduction is stable, but immobilization of the neck in a cervical collar is advisable for a few weeks.

Bilateral Dislocations and Fracture-Dislocations. With these injuries, cord damage is likely but not inevitable. Dislocation may be complicated by a fracture of the articular processes, or a compression fracture of the vertebral body

Treatment If there is no paraplegia the treatment of choice for bilateral dislocations and fracture-dislocations is skeletal traction applied to the skull This may be done in two ways (*a*) by skull calipers (Fig. 15 10), and (*b*) by zygoma traction made by small metal hooks inserted beneath the

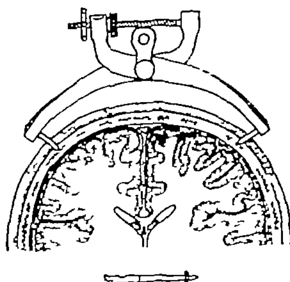


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Fractures of Special Vertebræ. *The Odontoid Process* Fracture of this process of the axis or dislocation by rupture of the transverse ligament of the atlas may cause sudden death. One of these injuries is usually found at autopsies in cases of judicial hanging.

The Atlas Fractures are so rare as to need no mention here

Hyperextension Injuries. Paraplegia is sometimes due to hyperextension of the cervical spine The accident may be a fall downstairs in which case the patient may be concussed and a bruise may be visible on the forehead A similar accident can occur for instance when a bather is struck by a large wave and rolled over backwards. Radiological examination of the neck may show nothing abnormal but at autopsy the anterior common ligament is found to be ruptured, so that the vertebral bodies may easily be separated by hyperextension When this happens the cord is stretched and the cause of the paraplegia is apparent.

In a paraplegic patient great care must be exercised when taking skiagrams of the cervical spine for if the head is allowed to fall back sudden death may occur

THE PELVIS

Fractures of the pelvic bones are almost always the result of direct injury such as falls, blows, gunshot wounds or crushes in motor or aeroplane accidents. For convenience they may be described under a number of headings.

Fracture of the False Pelvis. A portion of the iliac crest may be broken off the anterior superior spine separated or merely a fissure in the bone produced. The displacement is rarely great. Considerable pain is always present, especially on any vigorous respiratory movements, but crepitus is rarely detected. Union occurs readily if the patient is kept quiet in bed with the shoulders raised and the legs supported to relax the abdominal muscles. A pelvic binder gives comfort

Septic penetrating wounds, such as those following gunshot injuries, are liable to result in a subacute spreading osteomyelitis which is most troublesome. An abscess may form on the inner aspect communicating with the exterior by a narrow passage in the bone made by the penetrating body

Fracture of the True Pelvis. This is a more serious accident. The pelvic ring is interrupted When the fracture occurs at one place the stability of the



FIG 15 11 FRACTURE OF THE PELVIS THROUGH THE RAMI OF BOTH PUBES.

pelvis is not disturbed but if the ring is fractured at two places, considerable instability may result. There are three types of double fracture

(1) The pubic and ischial rami are fractured on both sides, thus isolating the symphysis pubis. The deformity is great (Fig. 15 11).

(2) The pubic and ischial rami are fractured together with the innominate bone in the region of the sacro-iliac joint. This is called the shear fracture. The half pelvis may be displaced upwards causing shortening of the leg (Fig. 15 12)

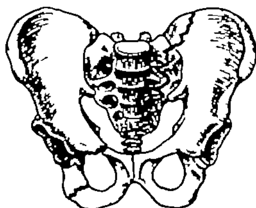


FIG 15 12. FRACTURE OF THE PELVIS.
The fracture runs through the sacrum and ilium on the left side, and through the pubis and ischium of the opposite side.



FIG. 15 13 SEPARATION OF THE SYMPHYSIS PUBIS.

(3) The pelvic ring may be split at the symphysis pubis, being hinged on the sacro-iliac joints. This type of injury results from falls astride a gate or being thrown from a motor cycle, when the impact is taken by the symphysis pubis. Rupture of the urethra or bladder is almost certain to occur (Fig. 15 13) The symptoms are those of severe shock with pain in and around the pelvis, especially on movements of the legs or on coughing. There may be local ecchymosis and tenderness over the pubic ramus, also deep in the iliac fossa, and the patient either cannot stand, or feels as if he were

falling to pieces on attempting to do so Usually there is little deformity although occasionally displacement backwards of the innominate bone is visible. Depression of the pubic symphysis or of the ischial or pubic rami may be palpable. Crepitus may be elicited on grasping the iliac bones and moving them one on the other

The chief dangers from a fractured pelvis arise from the presence of coexistent visceral lesions, especially to the bladder urethra or rectum. The membranous portion of the urethra is torn by the displacement of the pubic symphysis and this is indicated by escape of blood from the meatus. Every effort must be made to prevent extravasation of urine and *the patient warned against passing water however urgent the desire* Rupture of the bladder results in extraperitoneal or intraperitoneal extravasation, according to the site of the lesion The rectum may be punctured by the displaced pubic rami and on examination the ends of the bones may be felt in the rectum. The vagina and the pelvic vessels and nerves are less frequently injured.

The patient should be moved with the greatest possible care both on account of the shock and also for fear of producing or increasing visceral complications. As a first-aid measure a binder may be fixed round the pelvis. He is put to bed on a divided mattress with fracture-boards beneath. The treatment of shock is the first consideration, followed by that of the complications, and finally that of the fracture in this order

A very careful examination is made to exclude visceral injuries.

Visceral Injuries. A very careful examination is made to exclude these. The following are the most important

Rupture of the Bulbous Urethra. This is the common site for rupture to occur There is bleeding from the meatus, together with swelling and bruising in the perineum. Under full aseptic technique an attempt is made to pass a catheter if successful, a partial rupture of the urethra is likely and the catheter should be left in for some fourteen days. The presence of a hæmatoma in the perineum may lead to fibrosis or infection, both of which conditions favour the formation of strictures. The hæmatoma should therefore be evacuated, but it should be remembered that the incision will be made through erectile tissue, which is very vascular For this reason the wound should be lightly packed and suture of the skin delayed for a day or two

If the catheter fails to pass, a complete rupture is probable. A suprapubic cystostomy should be performed and the urethra repaired from the perineum, around an in-dwelling catheter

Rupture of the Membranous Urethra. When this part of the urethra is torn, great difficulty may be experienced in approximating the ruptured ends. This is because the prostate and bladderneck tend to fall upwards and back wards. The signs of the injury are similar to those of an extraperitoneal rupture of the bladder and the passage of a catheter in the normal way is impossible. The following procedure should therefore be adopted

The bladder is opened above the pubis, and a catheter or sound passed from it, in a retrograde manner A second instrument is passed along the penile urethra to meet the first. In this manner the instrument from the penile urethra is made to enter the bladder so that now a catheter attached to it can be drawn downwards to emerge at the meatus. If necessary this catheter may be of the Foley type with an inflatable bag so that traction applied, at the penile end of it, will assist in approximation of the ruptured urethra.

Since urethral ruptures are likely to be followed by stricture formation, routine dilatation by bougies should be carried out.

Extraperitoneal Rupture of the Bladder This is recognized by the inability to withdraw urine on passing a catheter or the withdrawal of only a little blood-stained fluid and the extravasation of fluid into the tissues above the pubis. Treatment consists in exploration and repair of the rent with perhaps suprapubic drainage If the fluid in the tissues has been present for some time and infection has occurred wide incisions for drainage will be necessary

Intraperitoneal Rupture of the Bladder This gives rise to similar findings, but shock is much more marked and there may be signs of fluid in the abdomen or of general peritonitis. Exploration is required the rent in the bladder being repaired and the peritoneum closed, an extraperitoneal suprapubic cystostomy then being instituted



FIG 15 14 FRACTURE OF THE HEMIPELVIS WITH UPWARD DISPLACEMENT OF THE SACRO-ILIAC JOINT

Damage to the Rectum If severe this demands a temporary colostomy but otherwise the case should be treated expectantly If the pararectal tissues become infected, wide incisions will be necessary

Treatment of the Fracture. Stable fractures, with a single break in the continuity of the pelvic ring, need no special treatment. The patient should stay in bed for two or three weeks until the pain has passed off At this stage he is ready to sit out of bed and to walk a few days later

Unstable fractures, on the other hand, need more careful attention.

Double Fracture of the Pubis and Ischium A firm pelvic binder adds comfort. Compression of the pelvis by a sling is to be avoided owing to the danger of closing the ring still further The displaced central portion will unite but the distorted ring may prevent normal childbirth Attempts at reduction of the displacement by manipulation are difficult and open operation is rarely necessary or advisable. From two to three months bed rest are necessary before the patient will be ready to walk.

Shear Fracture with Upward Displacement of the Hemipelvis This injury will require traction on the affected leg to minimize the shortening

(Fig. 15 14) Skeletal traction from the femur is advisable, as the pull will have to be heavy The lower end of the bed is raised to provide counter traction The patient should not bear weight for three months

Hinge Displacement with Split Symphysis In this type the treatment of the urethral or bladder injury is of prime importance. The patient is likely to require a suprapubic drain Treatment of the bone deformity must be adapted accordingly The best method of closing the open ring is to pass a broad canvas sling beneath the pelvis. The four corners of the sling are held apart by strainers hemmed into the canvas, and are suspended to a double overhead frame by cords and weights. The weights should be slightly less than is necessary to lift the patient from the bed but enough to make this action easily attained by one nurse. When the cords are arranged vertically no pelvic compression is obtained but by approximating them, as



FIG. 15 15 FRACTURE OF THE ACETABULUM WITH AN ASSOCIATED ISCHIAL FRACTURE.

much pelvic compression as is required, is easily obtained. This method controls the pelvis efficiently and at the same time allows easy access to the suprapubic area.

Bed rest will be required for from two to three months Persistent sacro-iliac pain may necessitate the wearing of a belt, or if severe, a fusion of the joint by operation.

Fracture of the Acetabulum. This is of two types

(1) A fissure fracture involving the acetabular floor This may be caused by a blow on the great trochanter or associated with a fracture of the rami of the pubis or ischium (Fig. 15 15) There is no displacement of the femoral head, but a traumatic arthritis of the hip joint with blood in the joint, must be treated by skin traction to the leg for four weeks. This is followed by a further period of two to four weeks before weight bearing is allowed.

(2) A fracture-dislocation of the hip joint. Two varieties of this occur

(*a*) Fracture of the posterior lip of the acetabulum with *dislocation of the* femur (Fig. 15 16) This is caused by a force transmitted along the femoral shaft when the hip is flexed, as when sitting in a car When the crash occurs



FIG 15 16 FRACTURE DISLOCATION OF THE HIP JOINT



FIG 15 17 FRACTURE-DISLOCATION OF THE HIP JOINT AFTER OPERATIVE FIXATION OF THE BONE FRAGMENTS BY SCREWS

the passenger's knee is thrown against the dash board, and sometimes the patella is also injured. The driver of the car does not suffer the injury as the thrust in his case is taken by his chest against the steering wheel.

The dislocation may be reduced by traction but is unstable and will recur unless continuous traction is maintained until the posterior lip has united. Failure to obtain reduction or accurate reposition of the fracture will require an open operation to fix the posterior lip in position by means of a screw (Fig. 15 17). The proximity of the sciatic nerve to the femoral head makes sciatic paralysis a possible complication of the injury

(*b*) Central dislocation of the hip The femoral head is driven through the floor of the acetabulum by a fall on the trochanter or occasionally as a result of electroconvulsion therapy in the fragile or elderly Attempts at reduction by traction are rarely successful and the usual end result is fibrous ankylosis. Pain may be treated by arthrodesis.

Fracture of the Tuber Ischii. This has been known to occur from falls in the sitting position The diagnosis is often obscure, as the displacement is slight.

Fracture of the Sacrum. This is always due to direct violence of considerable severity such as kicks, blows or gunshot wounds. It is usually comminuted and may be accompanied by injury to the bladder or rectum damage to the lower sacral nerves may result in incontinence. In the transverse fracture, the lower fragment is usually displaced forwards and may cause pressure upon the rectum Irregularity in the shape of the bone may be detected by rectal examination or from without.

Treatment The lower fragment should be replaced if possible, but considerable difficulty may be experienced in keeping it in position. A well fitting pelvic band, and rest in bed is probably all that is necessary Injury to the rectum with fæcal contamination of the wound requires colostomy

Fracture of the Coccyx. This may occur during parturition or result from falls or blows. Great pain is felt on walking, or on any movement which increases the intra-abdominal pressure, such as sneezing, coughing or defæcation, since the coccygeus muscle forms part of the pelvic diaphragm. A rectal examination reveals mobility of the lower fragment, angular deformity and perhaps crepitus.

Treatment This consists in keeping the patient at rest until union has occurred It is impossible to apply any apparatus, and hence the bone may unite at an angle, causing pain, discomfort, and difficulty in parturition. Excision of the bone is then required.

Coccydynia. Falls upon the coccyx, unaccompanied by fracture, sometimes give rise to a most severe and intractable type of neuralgia, known as coccydynia. This is confined almost entirely to women who may exhibit other neurotic tendencies. Sitting on a hard chair is uncomfortable but seldom prevents the patient from continuing her usual occupation. The symptoms gradually subside whatever treatment is adopted and excision of the bone is best avoided if at all possible.

Chapter 16
INJURIES OF THE LOWER LIMB

Fractures of the Femur

These are conveniently considered in three groups, affecting the *upper end shaft* and *lower end* of the bone. The femur is a large bone subjected to great stress during walking and weight bearing. Certain principles, applicable to all bones, are of particular importance when dealing with the femur Perfect *anatomical reposition is not necessary for full function* but the correction of angular deformity is of great importance Persistence of angulation will lead to abnormal stresses in the hip and knee joints with the inevitable onset of osteo-arthritis. Shortening, while of little importance in the arm, becomes serious in the leg, because of limp, pelvic tilt and consequent scoliosis. While up to half an inch of shortening is of little consequence, more than this amount will necessitate the wearing of a raised shoe. It is often necessary to accept some shortening when treating femoral shaft fractures by conservative methods. The alternative of internal fixation by open operation is perhaps seldom justified for this It should be reserved for patients in whom it is impossible to obtain apposition of the fragments because of the intervention of soft tissues between them.

Fractures of the Upper End of the Femur

Intracapsular Fractures

There are two sites at which fractures occur (*a*) subcapital, and (*b*) midcervical. These are most frequently met with in persons of advanced age, and especially in women This is explained by the atrophic changes which take place in the cervix femoris of elderly people. The spaces between the bony cancelli are enlarged and loaded with soft fat, whilst the ensheathing compact tissue is thinned and the "calcar femorale" of Merkel, *i.e* the process of thick cortical substance running from the lesser trochanter to the under part of the head, is atrophied It often requires little violence to produce this fracture, the causative accident being merely some slight stumble or fall, such as slipping off the kerb or tripping upstairs the bone yields and the patient falls to the ground. The line of fracture varies, being either transverse or oblique, and is intracapsular

The blood supply to the head of the femur comes mainly from below either *via* the femoral neck or by vessels carried in the capsule of the joint. A small vessel may sometimes remain in the ligamentum teres of elderly patients, but if present it supplies only a small portion of the femoral head. *When a fracture occurs, vessels are torn and the blood supply of the femoral* head will depend upon the amount of capsule remaining attached to it. Further damage may occur from attempts to use the limb, delay in treat ment, or at the time of manipulation to reduce the deformity Loss of blood

supply to the femoral head will result in *avascular necrosis* but this may not become apparent for several weeks A skiagram taken at six to eight weeks after injury may show increased density of the head (Fig. 16 1) or the condition may be suspected by extrusion of the nail with which the fracture will have been fixed The avascular head is likely to be followed by non-union of the fracture but revascularization is possible and union may occur but with some shortening of the femoral neck Degenerative changes in the articular cartilage, resulting in osteo-arthritis are inevitable.

Diagnosis The history given in both cases of some trivial injury is similar and there may be a certain amount of shock associated with the pain of the fracture On examination in the majority of cases, the limb is rolled



FIG. 16 1 AVASCULAR NECROSIS OF THE FEMORAL HEAD WITH NON-UNION.

out in a position of eversion, this being largely due to the action of gravity Some adduction is also present. Shortening of the leg by half an inch or so may be demonstrated by a measurement taken from the anterior superior iliac spine to the internal malleolus.

Any patient, particularly if elderly who gives a history of stumbling, falling or twisting the leg and who has pain in the region of the hip, should be suspected of having a fracture, until proved otherwise by good antero-posterior and lateral skiagrams. Ability to walk, or to lift the leg from the couch is not evidence against the presence of a fracture. Physical signs may be misleading or difficult to interpret in the obese patient.

The differential diagnosis should include contusion with traumatic arthritis and trauma to the already osteo-arthritic joint. Dislocation of the hip is rare at any age and unlikely in the elderly When doubt exists, radiography will provide the answer

Subcapital Fractures. Two types of subcapital fractures are recognized

Abduction Subcapital Fracture This type constitutes 20 per cent. of cases. The neck is abducted, relative to the head and impacted into it




A B

FIG. 16 2 ADDUCTION SUBCAPITAL FRACTURE OF THE NECK OF THE FEMUR.
A, ANTERO-POSTERIOR VIEW B, LATERAL VIEW




A B

FIG. 16 3 ADDUCTION SUBCAPITAL FRACTURE AFTER PINNING
A, ANTERO-POSTERIOR VIEW B, LATERAL VIEW

The physical signs are minimal and the patient may have walked on the limb. In many cases relief from weight bearing for ten to twelve weeks is all that is necessary There is a tendency for some of these fractures to disimpact and to become adduction fractures, it may therefore be wise to nail them. Partial weight bearing may then be allowed after six weeks.

Adduction Subcapital Fractures These account for 80 per cent. of cases. The routine treatment of adduction fractures is by Smith Petersen nailing (Figs. 16 2 and 3) The object is to provide rigid internal fixation of the

head to the neck of the femur by a tri-fin nail which prevents rotary movement and which can be introduced through a small incision. Operative shock is minimal and the patient can be up in a chair within a few hours Thus the complications of bed rest for a senile patient can be largely avoided It is wise to operate as early as possible before the development of bed sores, pneumonia or urinary infection Preferably this should be done on the day of admission to hospital If delay is unavoidable skin or skeletal traction should be applied as a temporary measure, which helps to reduce the deformity and to make the patient comfortable Non-union is practically certain without nailing. The operation offers a chance of union by bone in about 70 per cent. of cases.

The patient should be up in a chair each day and movements of the limbs



FIG. 16 4 McMURRAY'S OSTEOTOMY FOR NON-UNION OF A FRACTURE OF THE FEMORAL NECK.

are encouraged to prevent thrombosis. No weight bearing is allowed until there is radiological evidence of bony union this may take three months or longer Avascular necrosis of the femoral head is a common sequel to this fracture, followed by non-union When this happens the nail is often extruded because of absorption and shortening of the femoral neck. The nail should be removed. It may then be wise to accept non-union, or in a few cases an operation may be done. If the patient is unfit for operation, it is best to ignore the fracture and after a week or so in bed, to get her up as soon as pain allows. It is surprising how well an old lady with a comminuted fracture may get about. Prolonged bed rest does no good to the fracture and is the cause of bed sores, pneumonia, venous thrombosis and mental deterioration.

If an operation is decided upon, McMurray's displacement osteotomy is performed at the level of the lower part of the femoral head (Fig. 16 4)



FIG. 16 5 PSEUDARTHROSIS AFTER EXCISION OF THE HEAD AND NECK OF THE FEMUR.

The shaft is displaced medially *beneath* the head The limb is immobilized in plaster or by internal fixation until union of the trochanter to the shaft is firm. Stiffness of the knee is a complication. Alternatively the head and neck may be excised and a pseudarthrosis formed (Fig. 16 5)

Extracapsular Fractures

Basal Fracture of the Neck. The basal fracture may be intracapsular in front and extracapsular behind owing to the anatomical arrangement of the capsule in this situation. It is usually the result of violence acting trans-



FIG. 16 6. BASAL FRACTURE OF THE NECK OF THE FEMUR.

versely upon the greater trochanter as from a heavy fall upon the hip Th posterior part of the neck being weaker than the anterior first gives way the whole neck then yields and the severed head and neck are impacte into the junction of the trochanter and shaft (Fig. 16 6) The majority of thes fractures are thus primarily impacted continuation of the violence producin disimpaction, coupled either with detachment of one or both trochanter or with comminution of the great trochanter at least three and perhap four fragments are thus produced Disimpaction may also follow at later date from the rarefaction associated with the early stages of repair o from injudicious manipulation thus the shortening, which may at first b slight, often increases at the end of a few days. The upper fragment remain in the acetabulum, while the lower end is drawn up and everted

Union of the fragments is much more certain in this variety than in th transcervical and it is often accompanied by a considerable developmen of new callus. Secondary bending and late increase of the shortening ma occur if the patient walks too soon The deformity is that of *coxa vara*

Intertrochanteric Fracture This fracture is found in a somewhat younge age group than cervical fractures. The fracture line runs from the under sid of the neck, upwards and outwards. The lesser trochanter may be detache and pulled away by the psoas muscle (Fig. 16 7) Shortening may be con siderable due to upward displacement of the lower fragment which is reall the shaft of the femur The limb will be everted and crepitus may be fe when it is moved

In stout subjects clinical diagnosis between intracapsular and extra capsular fractures and a subtrochanteric fracture of the upper end of the shal may be difficult A *subtrochanteric* fracture is situated just below the lesse



FIG. 16 7 INTERTROCHANTERIC FRACTURE WITH COXA VARA DEFORMITY
The lesser trochanter is detached and displaced by the pull of the psoas muscle.



FIG 16 8. INTERTROCHANTERIC FRACTUR TREATED BY COMBINED NAIL AND PLATE

trochanter The upper fragment is flexed and abducted and is difficult to control by external splinting. It may be treated in the same way as an extracapsular fracture, by internal fixation.

Signs and Symptoms The basal and intertrochanteric fractures may be contrasted

The signs of local trauma, *viz* pain, bruising, and swelling, may be present in both but while slight in the basal variety they are often very marked in the intertrochanteric.

Crepitus is evident in the unimpacted forms of each but it is unnecessary and, indeed extremely unwise to elicit it by manipulation especially in the basal variety

Loss of power is perhaps more marked in the intertrochanteric form than in the basal. Cases of the latter in which the patient has been able to

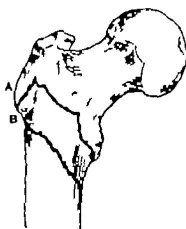


FIG. 16 9 A, INTERTROCHANTERIC FRACTURE OF THE FEMUR
B, SUBTROCHANTERIC FRACTURE.

walk into hospital some days after the accident are not unknown, and are probably due to impaction.

Eversion is a most characteristic feature in both varieties, the limb lying on its outer side except in the adduction variety of basal fracture. This displacement is accredited to the natural weight of the limb to the greater fragility of the back of the neck, causing it to be more comminuted than the anterior surface, and lastly to the greater power of the external rotator muscles.

Shortening is slight in the early stage of basal fractures, and much greater in the intertrochanteric, even reaching to 2½ or 3 inches (6 or 8 cm.). It is indicated by displacement of the trochanter upwards due allowance being made for the position of the limb as regards abduction or adduction

The position of the great trochanter is of importance. It is raised above its ordinary level, and displaced backwards owing to eversion of the limb.

Treatment There are two methods of treatment (*a*) conservative and (*b*) operative.

The conservative method consists in maintaining wide *abduction* of both hips with, at the same time, continuous traction on the injured limb Abduc-

tion may be arranged on an abduction frame or by the application of a Thomas's splint on each leg. Traction may be skin or skeletal. Three months is necessary for union, and a caliper may be required subsequently until consolidation is complete.

Operative fixation by a combined trifin nail and a femoral plate offers a firm method of internal splinting and enables the patient to sit in a chair and move about at an early date. No external splinting is needed. The operation is rather more severe than that for nailing a cervical fracture.



FIG. 16 10. SUBTROCHANTERIC FRACTURE OF THE FEMUR IN A PATIENT WITH PAGET'S DISEASE, TREATED BY INTRAMEDULLARY NAILING.

The time of union is not hastened. Alternatively intramedullary nailing may be employed (Fig. 16 10).

Fracture of the Great Trochanter. *This is rare, and always due to direct violence;* in the young it occurs as an epiphyseal lesion (Fig. 16 11). The trochanter, or a portion of it, is separated from the rest of the bone without *any loss of the continuity of the shaft.* Independent movement of the fragment with *crepitus is usually obtainable.* *If the displacement is at all marked* an operation to fix it should be undertaken.

Fracture of the Lesser Trochanter. This results from muscular violence and is associated with pain over the inner and upper part of the thigh and inability to *flex the thigh when sitting down. Treatment consists in immobilizing* the thigh in flexion and internal rotation for a month.

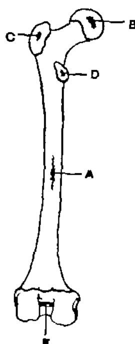


FIG 16 11 CENTRES OF OSSIFICATION OF THE FEMUR.

A, For shaft, eighth week of intra-uterine life B, for head, first year fusing with shaft at eighteenth year C, for great trochanter third year fusing with shaft at eighteenth year D for lesser trochanter twelfth year fusing with shaft at eighteenth year E, for lower epiphysis, at birth, fusing with shaft at twentieth year

Dislocation of the Hip Joint

The injury has become more common in this age of mechanization.

The accident occurs in young adults and occasionally in children, since older people sustain more readily a fracture of the femoral neck. There are two varieties of dislocation, (*a*) posterior and (*b*) anterior (Fig. 16 12). These are produced by two types of injury The more common is a longitudinal force applied to the femoral shaft when the hip is flexed and adducted This accident may happen in a motor crash when the passenger's knee is forced against the dash-board (see fracture-dislocation of the hip p. 370) or from a roof fall on to the back of a coal-miner The result is a posterior dislocation. The less common injury occurs from forced abduction of the thigh and will result in an anterior dislocation.

Posterior Dislocation of the Hip. The femoral head lies on the dorsum ilii or occasionally in the sciatic notch. The leg is held in flexion, adduction and internal rotation (Fig. 16 12, A) and lies across the opposite thigh. There will be considerable shortening, sometimes as much as three inches. Movement will be impossible and the femoral head may be felt deep in the buttock with a corresponding hollow in the femoral triangle. A skiagram will confirm the diagnosis and exclude the presence of a fracture of the acetabular margin (Fig. 16 13)

The sciatic nerve is occasionally damaged and the signs of this injury must be looked for before the dislocation is reduced

Treatment The patient is anæsthetized and lies supine, upon a mattress

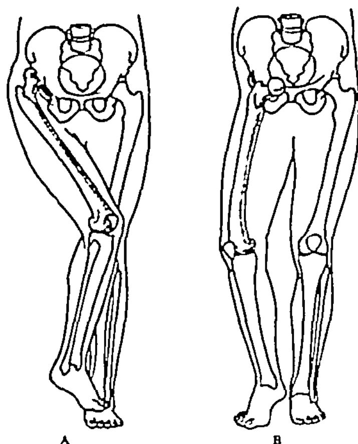


FIG. 16 12. DISLOCATION OF THE HIP
A, POSTERIOR DISLOCATION. B ANTERIOR DISLOCATION.

or the floor Complete relaxation of muscle is essential. The surgeon stands over the patient, while an assistant steadies the pelvis and makes counter traction upon it. The leg is flexed to a right angle and rotated to the neutral position and strong manual traction is applied in the long-axis of the femur This should lift the femoral head forwards into the acetabulum. After



FIG. 16 13 POSTERIOR DISLOCATION OF THE RIGHT HIP

reduction the leg is brought down into extension. Skin traction is applied with a weight of 10 lb (5 kg.) and this should be continued for six weeks. The patient must carry out quadriceps exercises during this period.

Fracture of the *acetabular margin* may also occur (p 370) If the fragment lies in good position after reduction, no other treatment is required, but weight bearing must not be allowed until the fracture is united. A displaced fragment may require internal fixation.

Anterior Dislocation of the Hip. The femoral head may lie on the pubic ramus or in the obturator foramen. The leg will be held in flexion, abduction and external rotation (Fig. 16 12, B) In the pubic position, shortening will be slight but in the obturator position, the limb may be lengthened The femoral head may be felt anteriorly

Treatment The patient is anæsthetized on the floor as for a posterior dislocation. The thigh is flexed to a right angle and rotated to the neutral position Instead of traction as for a posterior dislocation, the surgeon *applies pressure on the knee, thrusting the femoral head backwards* into the acetabulum. The after-treatment is similar to that for a posterior dislocation.

Central Dislocation of the Hip. This is discussed in the section on fractures of the pelvis (p 371)

Complications of Dislocations. *Fractures* Fractures of the posterior margin of the acetabulum are common and must be excluded by skiagrams before and after reduction

The femoral head may occasionally be fractured Dislocation of the hip may complicate a fracture of the femoral shaft and is likely to be missed in the presence of the more obvious injury

Avascular Necrosis A large part of the blood supply to the femoral head



FIG. 16 14 UNREDUCED POSTERIOR DISLOCATION OF THE HIP JOINT WITH OSSIFICATION OF THE CAPSULE AND A FALSE JOINT (PSEUDARTHROSIS).

is carried in the capsule of the hip joint. When dislocation occurs these vessels are torn and the remaining blood supply in the femoral neck may be insufficient. The onset of this complication may be shown in a skiagram as an increase of density of the femoral head about eight weeks after injury Sometimes the symptoms may be delayed for months or years In this case signs of osteo-arthritis may draw attention to the condition The incidence of avascular necrosis after dislocation of the hip is probably about 10 per cent.

Ossification of Ligaments As in other joints when ligaments are torn ossification is likely with resulting limitation of movement When pain is severe following avascular necrosis, osteo-arthritis, or ossification of ligaments, an arthrodesis of the joint may be necessary Fig. 16 14 shows a patient in whom an unreduced posterior dislocation led to a pseudarthrosis with ossification of the capsule.

Fractures of the Shaft of the Femur

General Characteristics. These fractures are common in spite of the apparent strength of the bone. Any portion of the shaft may be broken. Fractures of the upper third are often spiral, due to torsion, while those in the middle and lower third are usually due to direct violence and therefore transverse. Exact diagnosis by clinical methods is difficult owing to the thick muscles which clothe the bone and because of swelling.

Hæmorrhage is a serious matter in femoral shaft fractures and blood loss from the circulation into the soft tissues of the thigh in an adult may amount to several pints. A considerable degree of surgical shock may therefore be present. In addition fat embolism may occur

Deformity Transverse fractures are unstable and shortening may amount to 2 inches (5 cm.) or more. Angular deformity or bowing always presents considerable difficulty in treatment. After reduction stability must be provided by continuous traction until clinical union is obtained.

Operative Treatment Instability or difficulty in reduction makes this occasionally necessary It is always a serious procedure and one of the major operations of surgery only to be undertaken under ideal conditions. Blood loss may be considerable and facilities for blood transfusion should be available. Post-operative infection may have the most devastating consequences.

Reduction of the deformity will not produce stability which must be provided by a metal plate having four screws on each side of the fracture site. Alternatively an intramedullary nail may be used. This method is suitable for fractures of the upper and middle thirds of the shaft (Fig. 16 14). In lower third fractures the short lower fragment does not provide sufficient hold for the nail.

The indications for internal fixation are (*a*) fractures which are not easily controlled by external splinting or traction, *i.e.* subtrochanteric fractures (*b*) where soft tissue between the fragments prevents contact of the bones or (*c*) in pathological fractures in which healing is likely to be much delayed.

Open Fractures. Open or compound fractures are usually the result of penetrating wounds but occasionally result from penetration of the skin by the bone from within. High velocity missiles may penetrate cancellous

bone cleanly but striking cortical bone will cause shattering or comminution. In civilian practice they result from road, railway or machinery accidents.

Infection is likely to be troublesome owing to the lacerated muscle, hæmorrhage and depth of the wound, which provide ideal conditions for the anaerobic group of organisms. When bone infection is established necrosis is likely but sequestra separate slowly owing to the dense nature of the compact bone. Complications of bone infection in the femur are likely to be serious and include non-union, gross shortening and deformity and stiffness of the knee joint. Severe infection offers a serious threat to the life of the patient and may call for amputation of the limb

Fractures of the Upper Third of the Shaft

Spiral Fractures. The deformity is slight (Fig. 16 15). Small children may be treated on extension by Bryant s method (Fig. 16 25) or in a plaster spica.



FIG. 16 15 SPIRAL FRACTURE OF THE UPPER THIRD OF THE FEMUR IN A CHILD.

Six weeks is usually sufficient for clinical union. The child may be allowed to stand when he wants to, after the fixation has been removed.

In adults skin traction is sufficient, with the limb resting on a Thomas s splint. Eight to ten weeks may be necessary A weight relieving caliper is worn subsequently until the fracture is consolidated.

Transverse Fractures. These present a difficult problem in treatment.

The small upper fragment is flexed by the psoas and externally rotated by the gluteal muscles (Fig. 16 16) Alignment must be obtained by flexing the lower fragment at least 45 degrees and externally rotating it fully Traction must be applied in this position

Positive control of the upper fragment can only be obtained by open operation The fragments are aligned and fixed either by a six hole plate or by an intramedullary nail



FIG 16 16. FRACTURE OF THE UPPER THIRD OF THE FEMUR, SHOWING DISPLACEMENT OF BONE

Fractures of the Middle Third of the Shaft

These are often transverse fractures and slightly comminuted Two deforming forces must be overcome. Shortening requires continuous traction until clinical union is obtained probably in ten to twelve weeks. Bowing is always a problem. The shaft bows outwards because the adductor muscles stretch from the pelvis to the lower end of the shaft and act like the string of a bow This can be counteracted by arranging that the traction is applied with the leg in moderate abduction The distal fragment is displaced backwards (Fig. 16 18) and the normal anterior curve of the bone must be preserved by a large pad of wool placed beneath the fracture.

Treatment Traction may be exerted by either skin traction or skeletal traction

Skin Traction The skin is washed, shaved and dried The area to be covered with adhesive plaster is painted with friars balsam (Tinct. benzoin. co) as a protection against irritation by the adhesive. A special form of elastoplast, designed for skin traction, is available and is more convenient than ordinary zinc oxide plaster

Two wide strips are applied to the inner and outer aspects of the limb They should extend the full length of the limb and cover as wide an area of skin as possible without actually overlapping, but the strapping should never surround the limb so that there shall be no obstruction to the circulation.

The ends of the strapping are carried beyond the foot and attached to a spreader which consists essentially of a square of wood with a hole drilled

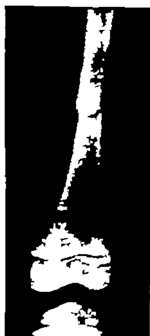


Fig. 16 17 Transverse Fracture of the Middle Third of the Femur.



Fig. 16 18. Lateral View of the same Fracture showing Posterior Displacement of the Distal Fragment

through the centre. Through this a length of cord is threaded, and is carried over the pulley at the end of the bed and a weight attached (Fig. 16 19).

Skeletal Traction. Traction is exerted directly through the bone by a Steinmann's pin or Kirschner's wire passed through the tibial tuberosity Traction through the lower end of the femur is to be avoided because in-

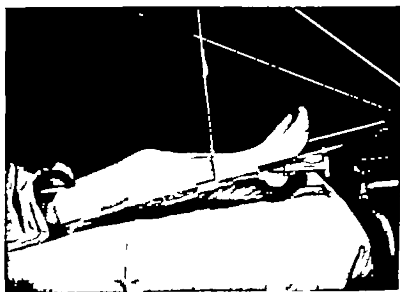


Fig. 16 19 Skin Traction applied for a Fracture of the Middle Third of the Femur. The Thomas's splint acts merely as a support for the limb. Counter traction is achieved by raising the foot of the bed.

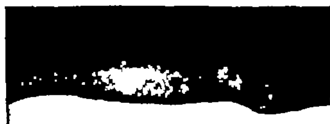


FIG. 16 20. SITES FOR THE APPLICATION OF SKELETAL TRACTION.

fection of the pin track may lead to stiffness of the knee (Fig. 16 20). The ends of the pin or wire are connected to a stirrup and through this extension is exerted (Fig. 16 21) Of all forms of extension this is by far the most satisfactory A more powerful pull can be exerted, blistering of the skin by strapping is avoided and wounds are easily accessible

Method of Reduction. It is important that correction of shortening and other displacement be carried out as a primary manœuvre while the patient is anæsthetized. The function of the weight extension should be merely to maintain this reduction, by balancing the tone of the muscles. Excessive weight may cause damage to the ligaments of the knee joint. The patient is anæsthetized, and skin or skeletal traction applied The ring of a Thomas s splint is slipped over the foot and slid up to the groin. Slings of bandage

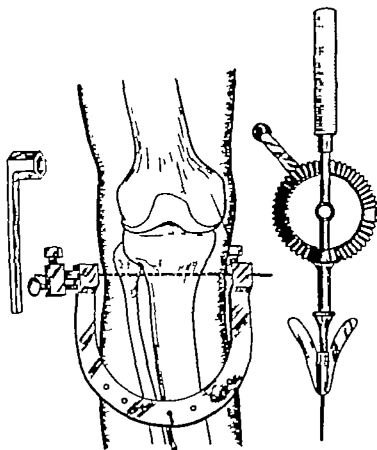


FIG. 16 21 KIRSCHNER'S WIRE, DRILL AND STIRRUP

are loosely pinned on the splint, to be adjusted later Strong manual traction is then applied either directly to the ankle or to the skeletal traction stirrup, and should be maintained steadily for several minutes. A weight of about 12 lb. (6 kg.) is attached to the limb and the manual traction relaxed. The bandage slings are then adjusted on the bars of the splint so that the normal anterior curvature of the femur is restored A pad of wool is placed behind the knee. Check radiographs are then taken and while these are being developed, the splint is counterbalanced to the overhead beam or frame, which should be ready in position. Minor adjustments to the weight extension and for correction of lateral displacement of the fragments can be made manually while the patient is still unconscious. For convenience the whole procedure



FIG 16 22. FRACTURE OF THE FEMORAL SHAFT
Weight extension on a counter-balanced Thomas's splint.

should be carried out in the patient s bed. *Distraction must be avoided.* Failure to obtain adequate reduction with good bone contact may necessitate open operation. The foot of the bed should be raised on blocks about 9 inches to prevent the patient from being pulled downwards and to provide counter traction by his body weight (Fig. 16 22)

This method of weight extension employs a Thomas s splint as a sling or trough in which the limb can lie. The splint plays no part in the extension which is exerted by means of a weight pulling against the body weight of the patient.

Another method sometimes employed consists of fixed extension. The strapping or stirrup is tied to the lower end of the splint, thus forcing the ring of the splint against the tuber ischii. By this means over riding of the bones is prevented. The method is useful for transport of the patient but has the disadvantage that pressure sores over the buttock may occur (Fig. 16 23)

The mattress on which the patient lies may be of the divided type, so



FIG 16 23 SKELETAL TRACTION. THOMAS'S SPLINT AND PEARSON KNEE HINGE.
The traction has been made by a Spanish windlass. Counter traction is made by the pressure of the ring of the splint against the tuber ischii.

that removal of the central portion permits of access to the back and buttocks, which can thereby be protected from bedsores, while bedpans can be more easily employed. From the start the patient is encouraged to move the hip-joint by hoisting himself with his arms into a position in which the hip is flexed by means of the support above the bed. Active contractions of the quadriceps must be carried out hourly throughout the day and hip and

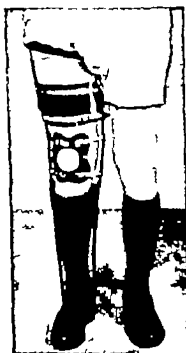


FIG. 16 24 WALKING IN A WEIGHT-BEARING CALIPER.
The ring takes the weight from the ischial tuberosity and the side bars transmit it to the heel of the shoe.

ankle movements encouraged. It may be wise to postpone knee movements for a few weeks. To enable movements of the knee to be made a knee hinge must be fitted to the splint (Fig. 16 23).

Traction in these cases needs to be continued for from two to three months, and it is better in the later weeks to remove the pin and replace the extension by strapping to avoid any possibility of infection *occurring in the* pin track. After some weeks the pin will have become loosened by bony absorption around it and the slight movement present is liable to encourage infection.

Following this a further three months is required in a walking caliper before full *weight-bearing is allowed, but in all cases the procedure must be* controlled by X-ray examination (Fig. 16 24).

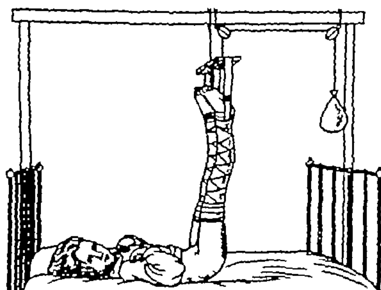


FIG 16 25 BRYANT'S METHOD OF EXTENSION FOR TREATMENT OF FRACTURE OF THE FEMUR IN SMALL CHILDREN.

The right leg is fractured, and has the weight attached to it the left leg is merely tied up to keep it vertical and out of the way

In *children* up to three years of age, Bryant's plan of treatment (Fig. 16 25) is excellent. In consists in slinging up the limb at right angles to the body from an overhead beam, utilizing the child's weight as the extending force. Adhesive plaster extension is applied to both limbs the sound leg is tied up out of the way the injured limb may be tied to the beam, or a weight passing over a pulley may be utilized. In any case the child's pelvis should just be lifted from the mattress so that the body weight acts as the extending force. This position is maintained for four to five weeks.

For the obstetric fracture of babies the best treatment is to apply a small padded splint on the *outer side of the thigh. Bryant's method is also* applicable, the baby's legs being tied to a light metal frame.

Fractures of the Lower Third of the Shaft

The lower third fractures which arise from direct force are transverse the lower fragment may then be tilted backwards by the gastrocnemii muscles (Fig. 16 26) and compress or rupture the popliteal vessels, even causing

gangrene. Oblique or spiral fractures from indirect violence sloping from above downwards and forwards, are also met with the upper fragment is driven into the substance of the quadriceps muscle and may become fixed in it, projecting immediately beneath the skin close to the upper border of the patella while the lower fragment is drawn up behind If such a fracture is left unreduced non-union is likely to ensue the knee joint is generally penetrated by the lower end of the upper fragment When the distal fragment is rotated backwards, traction is applied with the knee flexed on a hinged



FIG. 16 26. FRACTURE OF THE LOWER THIRD OF THE FEMUR.
The distal fragment is tilted backwards by the gastrocnemii muscles. This has been partially overcome by flexion of the knee.

Thomas s splint or on a Braun s frame (Fig. 16 41). Owing to the proximity of the fracture line to the knee joint, some stiffness is likely to follow this may be of severe degree and remain as a permanent disability

Knee Stiffness after Fracture of the Femur In general it may be said that the lower in the shaft is the fracture, the more likely is permanent stiffness of the knee. This is mainly because the gliding action of the quadriceps muscle is lost when it becomes adherent at the fracture site. Stiffness is much less due to adhesions in the joint, but this may be a factor if sepsis has occurred in the region of the suprapatellar pouch.

Active exercise is the best way of restoring knee movement and at least a year must elapse before the disability can be regarded as permanent. An operation to lengthen the quadriceps tendon may provide a partial solution to the problem.

Fractures of the Lower End of the Femur These are of several different types.

T or Y shaped Fractures of the Condyles In this a transverse fracture close to the knee is complicated by a fissure which runs into the joint, separating the two condyles more frequently a Y-shaped fissure may start from the intercondyloid notch. The condition is very painful, the joint is distended with blood the bone may feel broader than usual and crepitus may be detected on grasping the knee Comminution is not uncommon.

Treatment of Fractures Involving the Knee Joint The joint should be aspirated. Reduction is sometimes possible by skeletal traction exerted through the tibia, combined with manual compression of the femoral condyles The leg is supported on a Braun s frame (Fig. 16 41) or Thomas s splint with knee hinge, with the knee in about 30° of flexion and traction is maintained for six weeks. Movements may be started after three weeks. A weight bearing caliper should be worn until the fracture is consolidated. Open reduction and fixation of the condyles by screws or bolts is occasionally indicated.

Separation of Either Condyle. This usually results from direct violence, but occasionally has followed such an indirect injury as catching the toe against the kerbstone. There is no shortening, but the leg may be deflected towards the side injured and the knee-joint be full of blood. The fragment which is tilted backwards by the gastrocnemius may move separately from the shaft and give rise to crepitus.

Separation of the Lower Epiphysis of the Femur *This is a rare accident.* The limb is forcibly hyperextended at the knee and the epiphysis becomes detached and carried forwards. The lower end of the diaphysis projects behind and may compress the popliteal vessels gangrene has been known to result. As in the humerus, the line of separation does not always correspond to the epiphyseal line, but sometimes encroaches on the shaft. Reduction is effected by an assistant making traction on the tibia in the line of the limb so as to stretch the quadriceps then the thigh is gradually flexed by the surgeon, standing above and with both hands clasped beneath it. The epiphysis is by this means restored to its normal position and the limb may then be splinted in plaster with the knee flexed to about 60° Walking should not be permitted for at least six weeks.

Fractures and Dislocations of the Patella

The patella is broken either by (*a*) *direct violence* or (*b*) *muscular force* The conditions produced are so different that a separate description of each of them is necessary

Fractures by Direct Violence. These may traverse the bone in any direction, but are most often vertical or star-shaped and frequently comminuted. They are usually mere fissures without displacement, owing to the aponeurosis or capsule of the bone remaining intact There is a good deal of subcutaneous bruising, occasionally some effusion into the joint, while on careful palpation the fissure may be felt and crepitus occasionally detected.

Treatment This consists in keeping the limb at rest on a back-splint. Quadriceps exercises are started at once and active flexion of the joint may be permitted after fourteen days. Walking can be allowed after a month.

Fractures Due to Muscular Force. These are always transverse usually

complete and when they involve the fibrous aponeurosis, associated with considerable displacement (Fig. 16 27)

Mechanism When the knee is semi flexed the patella is poised upon the front of the condyles of the femur, resting upon the middle of its articular surface In this position any sudden and violent contraction of the quadri ceps, as in attempting to recover one s equilibrium after having slipped takes the bone at a disadvantage and may succeed in snapping it. Possibly in some people there is a predisposing weakness, as cases are not rare in which the other patella is broken at a later date. The fragments may be almost equal in size, but the lower is often the smaller either of them may be again divided vertically or comminuted



FIG. 16 27 TRANSVERSE FRACTURE OF THE PATELLA DUE TO MUSCULAR FORCE.

Signs There is loss of power of extension of the knee, pain, distension of the joint with blood and separation of the fragments, which can be readily felt and sometimes seen. This displacement is due to unopposed muscular action, and is not excessive unless associated with rupture of the lateral expansions of the vasti muscles. Union by bone is rarely obtained apart from operation, owing to the separation of the fragments and the carrying in of loose tags of the fibrous aponeurosis or capsule which yields at a different level to the bone. Fibrous union is the usual result and, when this is short and strong, it is quite satisfactory More commonly the bond of union slowly yields when the limb is used, so that the two fragments are once again separated, merely a bridge of fibrous tissue intervening. The joint is thus left in a weak state and the power of active extension of the leg much impaired or lost (Fig. 16 28).

Treatment Fibrous union will result unless accurate reposition of the fragments is obtained by operation. While at first satisfactory fibrous tissue tends to stretch with the result that the power of the quadriceps is progressively weakened. There are few patients unfit for operation, which should be undertaken as a routine.

The essentials of operation are to expose the fragments, to remove clot and aponeurosis trapped between them and to empty the joint of blood. Suture of the bones by wire was originally undertaken by Lord Lister but a screw may be used (Fig. 16 29). It is essential to suture the tears in the lateral expansions. Encirclement of the bone by catgut alone does not always maintain accurate apposition of the fragments

Comminuted fractures or transverse fractures in arthritic knee joints



FIG 16 28 FIBROUS UNION OF FRAGMENTS OF THE PATELLA. (*King's College Hospital Museum.*)



FIG. 16 29 FRACTURE OF THE PATELLA SUTURED BY A LOOP OF STAINLESS STEEL WIRE.
The skiagram is a "positive."

are treated by excision of the whole patella and suture of the quadriceps tendon to the patellar ligament. Active flexion may be started after two weeks but the patient should not try to lift the leg with extended knee for a month. Walking is permitted at six weeks.

Dislocation of the Patella. Traumatic dislocation is almost invariably lateral, due to the obliquity of the femur in relation to the tibia, but medial and upward displacements of the bone are described. The latter occurs when the patellar ligament is avulsed from its junction with the lower pole of the patella, or from the tibia elongation of the ligament will allow the patella to "ride high" on the femur

Lateral Displacement This is commonly seen in adolescent girls. The

dislocation may occur as a result of a direct blow on the inner side of the bone, when the knee is extended, or from muscle action during a strenuous game. Contributory factors are thought to be (*a*) a highly riding patella (*b*) laxity of the medial capsule, (*c*) poor development of the lateral femoral condyle, or (*d*) genu valgum. This deformity though seldom present to a marked degree, allows the line of pull of the quadriceps muscle to " bow string " towards the outer side of the joint.

The displacement may be partial or complete and occasionally the patella may be rotated through 90° and lie " on edge " against the lateral femoral condyle, where it may be easily felt. The knee appears flattened in front and broader than normal



FIG. 16 30. RECURRENT DISLOCATION OF THE PATELLA.
The patient, a woman of sixty-nine, had suffered from recurrent dislocation all her life. Marked osteo-arthritis is present.

Reduction may occur spontaneously or the bone may be replaced by manipulation. With the thigh flexed on the abdomen and the knee fully extended, slight pressure on the outer margin will cause the patella to slip back into place. Considerable effusion into the joint follows and this must be treated by a firm pressure bandage and quadriceps exercises, but walking should not be allowed for a few days.

Recurrent Dislocation. This may follow the primary incident, and is sometimes bilateral. This condition should be included in the differential diagnosis of " internal derangement " of the knee joint. When the symptom is one of locking or catching of the joint in a young girl, the diagnosis of subluxation of the patella is probably more likely than that of a meniscus injury A useful test is to observe the behaviour of the patella when the knee is extended against resistance. The unstable patella will shift outwards when the knee is a few degrees short of full extension. Examination under an

into the popliteal space and compressing the vessels, so that gangrene may follow The lateral popliteal nerve is stretched and a "drop foot" is a frequent complication The upper end of the tibia carrying with it the patella lies in front, forming a well-marked swelling with a hollow above it There is usually considerable shortening of the limb if the articular surfaces overlap

Backward Displacement. Dislocation of the tibia backwards is a much rarer accident and is also as a rule complete (Fig. 16 31) The signs are exceedingly characteristic, the pressure effects upon the popliteal vessels and nerves often resulting in gangrene, or paralysis.

Reduction of either of these conditions is easily accomplished by traction on the limb while the thigh is flexed, combined with manipulation in order to guide the head of the tibia into its normal position. The limb must subsequently be kept at rest in a plaster cast for a period of anything up to three months, according to the degree of initial injury The quadriceps muscles must be exercised throughout this period. If the joint is mobilized too early a flail joint may result.

Internal Derangement of the Knee Joint

This heading embraces a variety of traumatic lesions of the knee joint, but excludes gross trauma to the femoral or tibial condyles, patella or dislocation of the joint. The anatomical structures under consideration are the following

(1) The ligaments medial and lateral and the anterior and posterior cruciate.

(2) The medial and lateral menisci.

(3) The articular cartilage of the femur patella and tibia.

(4) The quadriceps extensor mechanism quadriceps tendon, patella and ligamentum patellæ.

(5) The infrapatellar fat pad.

(6) The synovial membrane.

(7) The joint capsule.

(8) The anterior tibial spine.

Type of Injury Certain types of injury may be followed by corresponding lesions the following are examples of these

Injury	*Lesion*
Valgus strain	Tear of medial ligament.
Valgus strain and rotation of tibia.	Tear of medial meniscus and/or tear of ligament.
Rotation of tibia inwards or outwards.	Tear of medial or lateral meniscus injury of articular cartilage
Direct blows	Bruised fat pad bruised synovial membrane bruised articular cartilage dislocation of patella.
Hyperextension of joint	Tear of anterior cruciate ligament or avulsion of bone at lower attachment near anterior tibial spine.
Violent contraction of quadriceps.	Quadriceps tendon torn from patella fracture of patella strain of attachment of ligamentum patellæ to tibia, or patella.

Injuries of Ligaments

The Medial Ligament. This is the ligament most often injured, because the femur is set at a slight angle to the tibia (valgum) owing to the fact that the hip joints are wider apart than the knee joints. Thus the medial ligament is subjected to greater mechanical strain than the lateral ligament.

The medial ligament may be torn at the level of the joint line or at its upper or lower attachments. When the upper attachment is torn, a hæmatoma may form beneath the periosteum of the femoral condyle. Ossification of this hæmatoma is known as *Pellegrini-Stieda's* disease, but needs no special treatment other than that required for the torn ligament. The medial meniscus is often injured at the same time. There will be local tenderness over the site of the tear swelling and pain when the tibia is abducted on the femur In complete tears the joint will be unstable. Adhesion formation between the ligament and the synovial membrane may result in chronic pain and recurring attacks of synovitis. This may be cured by manipulation.

Treatment The ligament must be protected from strain until healing is complete (three to six weeks). In minor injuries this is best done by raising the inner side of the shoe ¼ inch (0 5 cm.). In complete tears, a plaster cast is applied from groin to ankle. Secondly the effusion is limited and the joint supported by firm bandage or strapping. The tone of the muscles is maintained by active contractions and faradism.

The Anterior Cruciate Ligament. This is an intra-articular structure, attached below to the tibia near the spine and passing upwards, backwards and outwards to the femoral condyle. It is tense in extension and checks forward displacement of the tibia on the femur It also assists rotation of the tibia on the femur in the act of locking of the joint in full extension The signs of injury will thus be hyperextension of the knee, if other ligaments are also lax increased mobility of the tibia on the femur in the forward direction and an effusion into the joint. (If the tibia can be displaced backwards, a tear of the posterior cruciate ligament should be suspected) A skiagram may reveal that the lower attachment of the anterior cruciate ligament has avulsed a flake of bone from the tibia producing a fracture of the tibial spine (Fig. 16 35)

Treatment The knee is fixed in full extension for six weeks in a plaster cast. Open operation may be required to replace the lower attachment accurately or for late reconstruction of the ligament in cases of severe instability

Rupture of a Meniscus

This is a very common injury and usually occurs as a result of a side slip associated with torsion of the tibia upon the femur The accident is liable to happen when a player swerves while running, in football or tennis, or when a bed turn is made on skis. A tear may also occur with the knee fully flexed as when crouching in a mine.

Mechanism. The medial meniscus is less mobile than the lateral meniscus. This is due to the fact that it is anchored to the medial ligament, whereas the lateral meniscus is free to slip from the grasp of the femoral and tibial condyles. When the knee is twisted the menisci may become nipped and ruptured by the grinding action of femur upon tibia. The incidence of tears is greater in the medial than the lateral meniscus in the proportion of three

or four to one The menisci consisting of fibrocartilage are largely avascular structures except at their attachments. The majority of tears therefore cause little hæmorrhage into the joint and do not heal It is only when a tear occurs in the peripheral vascular zone that hæmorrhage is profuse and that healing can occur The presence of pure blood in the joint following an injury suggests either a fracture communicating with the joint, a rupture of an intra-articular ligament, a tear of synovial membrane or a peripheral tear of a meniscus.

The Lesion. The site of the lesion may be *an anterior or posterior* tear or a longitudinal split which leaves a narrow peripheral rim and a wider

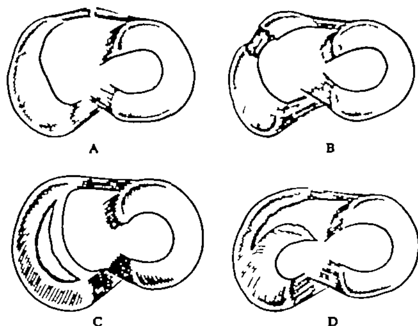


FIG. 16 32. DIAGRAMS OF VARIOUS TYPES OF INJURY SUSTAINED BY THE MEDIAL MENISCUS.
In A the anterior attachment has been stretched and torn, and the meniscus is consequently loose. In B the meniscus has been torn transversely across, and a weak cicatrix has formed. In C the meniscus has been split longitudinally (bucket-handle injury). In D the anterior end of the bucket-handle has also given way leaving a loose tag, *which often causes trouble.*

central portion attached in front and behind but free to move in a medial and lateral direction (Fig. 16 32) This is the typical "*bucket handle*" tear Occasionally the meniscus is split horizontally into an upper and lower portion, a type of injury which is difficult to see until the whole structure has been removed from the joint. Locking of the joint occurs when a mobile portion of the meniscus becomes jammed between the femoral and tibial condyles.

Symptoms When the accident takes place, a sudden sickening pain is felt in the knee. The patient may refer it to the inner or outer side of the joint, but is often uncertain of the exact location. *He may fall on attempting* to rise, finds that the joint is locked in flexion and cannot be extended fully He may be able to wriggle it free so that reduction occurs with a snap, or it may remain locked until the joint is manipulated under an anæsthetic.

The sequence of injury locking followed by unlocking, is diagnostic of

a mechanical block to extension of the joint and can be caused by bony or cartilaginous loose bodies as well as by a meniscus tear

Reduction of a locked knee means that the displaced portion of meniscus has slipped back into apposition with the rim or has been displaced into the intercondylar notch. In either case the knee unlocks. Further locking is likely if the joint is twisted suddenly and repeated lockings will damage the articular cartilage and favour the onset of degenerative arthritis.

The injury is followed by swelling of the joint. This consists of a synovial effusion which on aspiration is usually found to be clear but may be tinged with blood The significance of pure blood in the joint has been discussed above.

Wasting of the thigh muscles is rapid. In long standing cases, the combination of muscle wasting and joint instability produces a feeling of in-

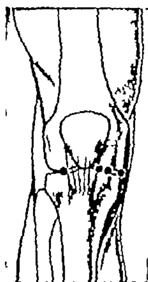


FIG. 16 33 POINTS OF TENDERNESS ON THE JOINT LINE IN LESIONS OF THE LATERAL AND MEDIAL MENISCI

security in the knee which the patient describes as " the joint lets me down."

Signs In a typical case there will be synovial effusion and muscle wasting. The joint may still be locked and held in slight flexion It may be warm. Points of tenderness should be sought with the knee in the semiflexed position (Fig. 16 33). These are found typically on the medial or lateral joint lines. Stability is tested by attempting to lift the tibia backwards and forwards on the femur The medial ligament is tested by abducting the tibia on the femur

Diagnosis The taking of a careful history is most important A twist, followed by pain and locking, is almost diagnostic of a torn meniscus. Sprains of the medial ligament may be accompanied by a medial meniscus tear but it may be difficult to be certain of the meniscus injury in the early stages. In girls, the history of a knee locking or " giving way " should suggest lateral dislocation of the patella as an alternative diagnosis. Momentary locking accompanied by sudden pain in an osteo-arthritic knee may be caused by nipping of a synovial fringe or by degenerative changes leading to fraying " of the meniscus rather than to a recent tear

In doubtful cases, a period of observation may be necessary The swelling

is treated by a pressure bandage. Aspiration may be carried out for diagnostic purposes as well as for the relief of tension in the joint, and the tone of the quadriceps muscle must be improved by frequent exercises. Provocative games or gymnastics may be given to "try out" the joint as well as to improve muscle tone. Locking may occur during these games and the surgeon is then able to examine the knee soon after the incident.

Radiography in cases of recent tears does not help except to exclude bony loose bodies. When there is a long history of locking, the skiagram may show narrowing of the joint space on one side of the joint, together with some early osteo-arthritic lipping. Air arthrography is used for diagnosis in some orthopædic centres but the interpretation of the films is difficult, and the method is of little value unless the surgeon uses the method on every case so that he becomes familiar with the normal as well as the abnormal appearances. The investigation is carried out by inserting a needle into the joint, aspirating any fluid present and injecting air into the joint cavity skiagrams are then taken from various angles and the menisci may be visualized

Treatment In the early stages this consists in complete reduction of the displacement by manipulation, if need be, under an anæsthetic. Unless the patient can extend the knee fully some displacement persists and subsequent trouble is sure to follow Reduction of a medial meniscus is effected by flexing fully both the knee and hip joints the leg is then everted fully and abducted so as to open up the joint interspace on the inner side. A rapid movement of inversion and extension usually brings about satisfactory reduction and complete extension is at once possible. Thus the full range of movements is restored.

Subsequent treatment consists in applying a firm pressure bandage to the knee, combined with rest, and later active contractions and electrical treatment will be required to tone up the quadriceps.

Operative Treatment Should the above methods fail, and the diagnosis of a torn or displaced meniscus be well established, operative treatment is required. A tourniquet is used. The patient's knee flexed to a right angle, hangs over the end of the operating table, and the surgeon sits facing it and supporting the foot between his knees. The meniscus is exposed, and its shape and mobility tested by picking it up on a blunt hook slipped under its free edge. Bucket handle tears are easily seen when displaced, but if the torn portion is lying in contact with the rim, the tear may not be obvious until a probe is inserted into the gap between them. It is often sufficient to remove the bucket handle portion only Posterior tears may be visible when the meniscus is drawn forward by a hook or may not be apparent until the whole meniscus is removed. Finally the articular surfaces of the patella, femur and tibia are inspected and also as much of the other meniscus as possible before the knee is closed.

After Treatment The knee is kept quiet on a pillow until the wound is healed, but active muscle contractions and faradism are started at once. The patient should not place his weight on the limb for ten to fourteen days at least. Physiotherapy must be continued until good muscle tone is restored. This may take six or eight weeks.

Cyst of the Lateral Meniscus. Cystic degeneration in the lateral meniscus may occur following an injury In the early stages the symptoms are those of a dull ache, usually worse at night, and situated on the outer side of the joint. Later a swelling is noticed lying on the outer joint line in front of the

lateral ligament. On examination it is found to be a tense cyst, tender on pressure transillumination is difficult unless the cyst is very large. Radiography is usually negative, but occasionally may show some pressure erosion of the outer edge of the tibia. On exploration the cyst is found to be composed of multiple loculi filled with jelly and microscopically has the same appearance as that of a ganglion.

Treatment This consists of removal of the whole of the lateral meniscus together with the cyst protruding from it.

Injuries to the Articular Cartilage

The articular cartilage may be injured by direct blows or by violence transmitted through the shafts of the bones. Severe damage may lead to degenerative arthritis.

Osteochondritis Dissecans. This is probably traumatic in origin but



A B

FIG 16 34 OSTEOCHONDRITIS DISSECANS AFFECTING THE MEDIAL CONDYLE OF THE FEMUR.

A, ANTERO-POSTERIOR VIEW B, LATERAL VIEW

whether by direct trauma to the cartilage or by trauma to the underlying blood vessels resulting in necrosis, is not decided The usual site is the outer side of the medial femoral condyle adjacent to the spine of the tibia (Fig. 16 34) An area of articular cartilage becomes softened and finally separates, leaving a crater about the size of a shilling. The floor of the crater consists of bare bone which is avascular and shows no sign of granulation tissue. The separated fragment becomes a loose body in the joint cavity and may cause " locking of the joint. It may grow in the joint fluid and constitutes one form of " joint mouse " or loose body Although mostly cartilaginous, the fragment may contain some flecks of bone and thus be visible in a skiagram

Symptoms There is usually a somewhat vague history of injury and the patient is often unable to date this event The immediate complaint is that of recurrent effusion and pain following exercise with occasional attacks of "locking." Tenderness may be elicited over the medial femoral condyle close to the patellar ligament A skiagram will usually settle the diagnosis Both knees should be examined as the condition is occasionally bilateral

Treatment When the knee is opened nothing abnormal may be seen. It is then necessary to locate the area of necrosis seen on the skiagram by means of a steel "marker" inserted into the articular cartilage so that its exact position can be visualized on a further skiagram A number of fine drill holes are then made into the area and the joint closed This will enable the avascular area to be revascularized and healing to take place.

If the area of necrosis is visible and the fragment loose, it may be possible to fix it back by means of a small nail or bone peg, while a completely detached fragment should be removed.

After any operative procedure, the joint should be guarded by a caliper for a few months. Recurrent effusion is common and the joint is unlikely to stand up to strenuous athletics, although a useful knee should be obtained.

Osteochondritis may occasionally be seen on the articular surface of the patella or tibia.

Chondromalacia Patellæ. This is a generalized softening of the articular cartilage of the patella, rather than a localized area of necrosis. If progressive, osteo-arthritis will result, and in fact chondromalacia may be an early stage of this condition. Chondromalacia may follow trauma or be insidious in onset.

The symptoms are those of pain beneath the patella after exercise together with a slight effusion into the joint. Crepitus may be felt when the patella is moved on the femur A mild type of this condition is seen in schoolboys who complain of pain after strenuous games.

Treatment The boy should be rested from games for a term or so When activity is again started the symptoms do not always recur For chondromalacia causing severe symptoms, excision of the patella is the best treatment.

Injuries of the Quadriceps Extensor Mechanism. These include avulsion of the tendon from the patella, fractures of the patella (p 392) and lateral dislocation of this bone (p 394). The ligamentum patellæ may be strained at its upper or lower attachment. At the upper end, a small area of new bone formation may be seen in a skiagram. Strains of the lower end are associated with an enlarged tender tibial tuberosity a condition known as Schlatter's disease (p 485).

Injury to the Infrapatellar Fat Pad. This pad occupies a space bounded in front by the ligamentum patellæ, on each side of which it projects. It is separated from the joint cavity by the synovial membrane, but projects backwards into it. This projecting portion may be nipped between the femur and the tibia. The subsequent swelling interferes with full extension of the joint.

Treatment The patient is made to walk with the knee slightly flexed by raising the heel of the shoe ½ inch (1 5 cm.) Alternatively the projecting portion of the fat pad may be removed

Bruising of the Synovial Membrane. This produces synovitis. It will usually resolve with rest and firm bandaging. A diagnosis of synovitis should

not be accepted until other causes of internal derangement have been considered In joints which are the site of thickened synovial membrane with villous processes (villous synovitis) a form of pseudo-locking may occur when one of these processes becomes nipped.

Tears of the Capsule. These may be associated with injuries to the medial ligament or to the quadriceps mechanism (*e g* fracture of the patella) Care should be taken to repair the torn capsule as well as the more obviously *injured structure.*

Fractures of the Tibia and Fibula

Since the tibia is the weight bearing bone of the leg, fractures of the fibula are relatively unimportant, except when they occur in the lower 3 inches (7 5 cm.) of the bone. In this situation, fractures of the fibula are liable to interfere with the stability of the ankle joint and thus become of great importance. They are considered under fracture-dislocations of the ankle.

Fractures of the Tibia

Fracture of the Tibial Spine. The spine is situated inside the knee joint, in the region of attachment of the anterior cruciate ligament. Sudden strains applied to the cruciate ligament by hyperextension, or by a blow which forces the femur backwards on the tibia, when the knee is bent, cause rupture of the ligament or avulsion of a portion of tibia containing the spine. The injury *occurs in adolescents. The joint rapidly fills with blood and it is obvious that*

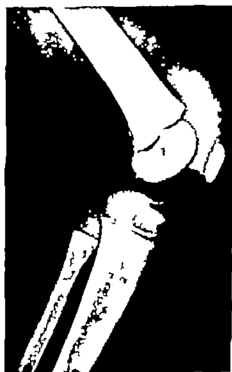


FIG. 16 35 FRACTURE OF THE TIBIAL SPINE.
A flake of bone has been avulsed by the anterior cruciate ligament in a hyper extension injury of the knee joint.

some internal derangement has occurred A lateral skiagram will show the flake of bone lifted from its bed (Fig. 16 35)

Treatment An anæsthetic should be given and the joint aspirated The knee is then extended fully, but not hyperextended and a lateral skiagram taken If the flake of bone has been pressed home by the femoral condyles, a plaster cast is applied from groin to toes for two months. Quadriceps exercises should be practised during this time. In the event of failure to obtain accurate reposition of the fragment, an open replacement will be necessary Malunion with new bone formation may block full extension of the joint.

Fractures of the Tibial Condyles. These are fractures of adults. They



FIG. 16 36. FRACTURE OF THE LATERAL CONDYLE OF THE TIBIA.

involve the tibial plateau and are referred to as "plateau" fractures or "bumper" fractures because they are sometimes caused by a blow on the side of the knee by the bumper of a car One or both condyles may be fractured, but usually the lateral condyle is involved. This is because a valgus or knock knee strain is more common than the reverse injury The medial ligament may be torn and the lateral femoral condyle is forced on to the tibial plateau displacing a triangular fragment downwards (Fig. 16 36). The lateral meniscus may be wedged between the fragments. The joint will be filled with blood and there will be a knock knee (valgus) deformity Under an anæsthetic lateral instability of the tibia can be demonstrated. Fracture of both condyles, together with the upper end of the shaft is a serious injury with much comminution of bone. The tibial condyles are splayed apart and the shaft may lie between them.

Treatment The deformity is corrected by manipulation and traction. If there is a gap between the fragments, an attempt is made to close this by compression between the hands or by means of a clamp. Blood is aspirated from the joint.

Two methods of treatment are then available (*a*) A plaster cast is applied from groin to toes for eight weeks, taking care to correct the knock-knee deformity while it is setting (*b*) Skin traction is applied to the leg, with a weight of 10 lb. (5 kg.). The thigh and leg are supported on slings to an overhead frame, and early movements of the knee are encouraged. By this means a better range of movement may be expected.

Whichever method is adopted, the patient may start to bear weight at eight weeks provided he wears a caliper until the fracture is consolidated, which may be for a further eight weeks. Operative replacement and internal fixation of the fragment is occasionally required. Osteo-arthritis is a likely sequel of this injury as of all fractures into joints.

Fractures of the Shaft of the Tibia. Direct or torsional violence may



FIG. 16 37 SPIRAL FRACTURE OF THE SHAFT OF THE TIBIA IN A CHILD.

produce transverse or spiral fractures the latter being common in children (Fig. 16 37) The bone is subcutaneous on its medial surface so that palpation is easy When the fibula remains intact, displacement is slight and the skin not often broken.

Treatment Manual traction and manipulation to correct deformity are usually successful. A plaster cast is applied from groin to toes with the knee flexed 15° *Children may* be allowed to walk in the plaster in about one

month, and adults with transverse fractures at about six weeks The time of union in adults will be about three months.

Oblique fractures with overlap may be treated by means of internal screw fixation when the skin is not broken

Fracture-Separation of Lower Tibial Epiphysis. This is an injury of adolescents. The fracture line is oblique in the tibial shaft and runs into the epiphyseal line. The epiphysis may be displaced (Fig. 16 38) Accurate reduction followed by fixation in a below knee plaster for six to eight weeks, is necessary Complications are unusual but arrest of growth may follow Deformity may result when this arrest is partial and subsequently may need correction by osteotomy

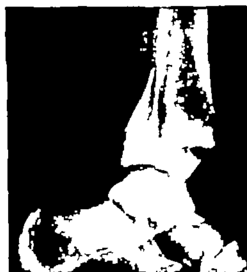


FIG. 16 38. FRACTURE SEPARATION OF THE LOWER TIBIAL EPIPHYSIS IN AN ADOLESCENT GIRL.

Fractures of the Fibula

These are due to direct violence and occur at the neck or in the middle of the shaft (Fig. 16 39) Fracture of the neck may be complicated by a lesion of the lateral popliteal nerve, producing a "foot-drop" and for this reason may require exploration

Treatment The fibula is not concerned with weight bearing and no splint is required Firm elastoplast strapping is all that is necessary for the comfort of the patient.

Fractures of Tibia and Fibula

These injuries are very common. There are two types which are due to (*a*) torsion, and (*b*) direct violence.

Torsion Fractures. When due to torsion, the tibia yields at the junction of its middle and lower thirds, and the fibula at a higher level The spiral fracture continues from one bone to the other across the interosseous membrane. It is important that the whole length of the tibia and fibula be included in the skiagram or the upper of the two fractures may be missed. The fracture may be open from within, the skin being perforated by a sharp spike of bone

Deformity consists of overlap or shortening together with some degree of rotation, so that the lower fragment is rolled out by the weight of the foot.

Fractures due to Direct Violence. Fractures of the tibia and fibula by direct violence is a common road accident. In the majority of cases the motor-cycle is responsible.

The force is often great, and there may be severe injury to the soft tissues. The fracture is nearly always open and comminuted. There may be severe shock and also considerable skin loss which makes closure of the wound



FIG. 16 39 FRACTURE OF THE SHAFT OF THE FIBULA CAUSED BY DIRECT VIOLENCE.



FIG. 16 40. FRACTURES OF THE TIBIA AND FIBULA CAUSED BY DIRECT VIOLENCE.

difficult. *Laceration of muscle is an important factor* in the slow union which is commonly experienced. Thus the picture is one of a comminuted fracture *of both bones, in which skin loss and muscle damage* contribute to the complicating factors of sepsis and poor blood supply to the bone resulting in delayed union. *Both bones are fractured at the same level* while lateral displacement with overlap is usual (Fig. 16 40)

Treatment Local treatment *is first directed at wound toilet.* An attempt should be made to close the wound or if this is not possible, at least to cover the bone with skin. *Relieving incisions in the calf may make this possible,* and skin grafting is necessary over muscle thus exposed

If the fracture is stable after reduction a padded plaster cast is applied from groin to toes, with the knee flexed 15° to 20° The cast must be split as considerable swelling is to be expected.

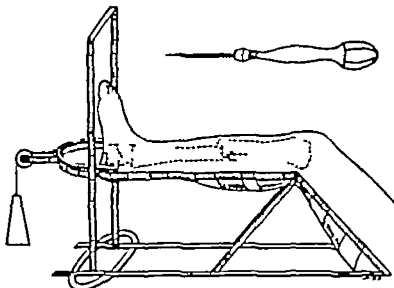


FIG 16 41 BRAUN'S FRAME.

The leg is supported on flannel slings. Traction is made from a pin passed through the calcaneum by the weight which hangs over the end of the bed. Counter-extension is obtained by tilting up the lower end of the bed on blocks. The shape of the splint ensures that the knee is kept flexed, but allows the patient to be propped up in bed with pillows. The pin and its introducer are seen above.

If the fracture is unstable, two procedures are available

(1) Continuous skeletal traction A Steinmann's pin is passed through the calcaneum or lower end of the tibia and the limb supported on a Braun's frame (Fig. 16 41) Weight traction of about 10 lb. (5 kg.) is applied to the

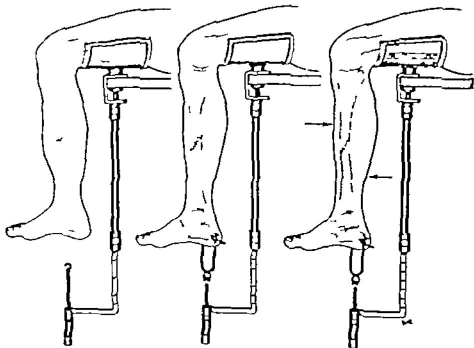


FIG 16 42. REDUCTION OF A FRACTURE OF THE SHAFT OF THE TIBIA BY TRACTION WITH A PIN THROUGH THE CALCANEUM (*Watson-Jones*)

stirrup The leg may be further stabilized by a posterior plaster slab Traction is continued until there is sufficient callus to stabilize the fracture, after which it is removed and a full-length plaster applied This method entails bed rest during the period of traction, which may be for six or eight weeks.

(2) The fracture may be reduced by some form of screw traction apparatus (Fig. 16 42) A second Steinmann's pin is passed through the upper end of the tibia. When reduction is complete a plaster cast is applied incorporating both pins, so that the deformity cannot recur If necessary four pins may be used (Fig. 16 43).



FIG. 16 43 A, UNSTABLE OPEN FRACTURE OF THE TIBIA AND FIBULA. B, THE FRACTURE HAS BEEN STABILIZED BY FOUR STEINMANN'S PINS. (Only three of these can be seen.)

Weight bearing in plaster is not allowed until the wound is healed, and the fracture has started to unite. The time at which this takes place is variable, depending on sepsis and blood supply In severe fractures union may take anything from three to six months, or longer Non-union is common Bone grafting for non union should be delayed until all wounds have been healed for at least three months.

Sprains of the Ankle

Sprains are a common form of ankle injury and are usually caused by a sudden twist of the foot when walking or running on uneven ground.

The foot is more readily inverted than everted so that the anterior fasciculus of the lateral ligament is torn. Sudden pain is felt, followed by swelling, below and in front of the lateral malleolus. The patient limps or is unable to walk. A bruise may appear in a few days.

Treatment When seen early before much swelling has occurred the ankle should be firmly strapped with the foot in eversion so that the torn ligament is relaxed The patient may be allowed to walk in a firm lace shoe but the ligament must be protected by strapping for three weeks. A local injection of anæsthetic solution is sometimes useful and may enable a patient to indulge in sport without pain In severe sprains a light ambulatory plaster of Paris cast will give better protection than strapping.

Recurrent Sprains. Failure to secure sound healing may result in a lax, unstable ankle joint There is a tendency for the ankle to twist over without



FIG 16 44 RECURRENT SPRAIN OF THE ANKLE.
The joint is unstable because the lateral ligament is elongated. Operative repair is indicated.

warning and the patient may be thrown to the ground. The instability of the joint can be demonstrated in a skiagram taken with the calcaneum held in full inversion The talus is seen to tilt to an angle of 20° or 30° (Fig. 16 44)

Treatment The wearing of an elastic anklet or firm bandage will give support. The outer side of the heel of the shoe is wedged ¼ inch and built out to give extra stability If these measures fail to give relief it is advisable to reconstruct the lateral ligament by operation.

Fractures in the Region of the Ankle Joint

These injuries are the result of indirect violence applied to the tibiofibular mortice, by wrenches or twists of the ankle. Four main types of injury are described in relation to the foot

(1) External rotation fractures.
(2) Abduction (eversion) fractures.
(3) Adduction (inversion) fractures.
(4) Posterior marginal fractures of the tibia, when the foot is forced backwards.

Types of Injury In considering displacement, the relation of the talus to the tibiofibular mortice is important. The talus may remain in its normal position or it may be displaced outwards, inwards or backwards, or be tilted. When such displacement is present, the injury is to be regarded as a *fracture-dislocation* The talus can be displaced outwards only if there is (*a*) a rupture

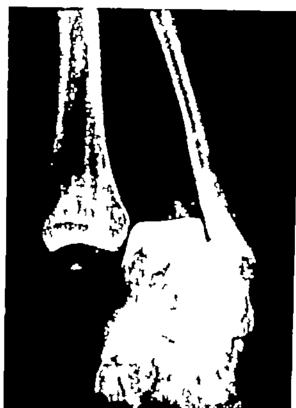


FIG 16 45 DIASTASIS OF THE ANKLE (DUPUYTREN'S FRACTURE-DISLOCATION).

of the medial ligament of the ankle or avulsion of the medial malleolus and (*b*) displacement of the lateral malleolus. This may be caused by (i) a fracture *through* the malleolus (ii) a fracture *above* the malleolus with tilt of the lower fragment or (iii) *diastasis* or rupture of the lower tibiofibular ligament. The various types of fracture and fracture-dislocation are illustrated in Fig. 16 46. Diastasis, with instability of the lower end of the fibula is much more common than would be supposed Ordinary antero-posterior

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FIG. 16 46. VARIOUS FORMS OF FRACTURE AND FRACTURE-DISLOCATION.

EXTERNAL ROTATION FRACTURE (FIRST DEGREE). A. The fibular fracture runs obliquely downwards and forwards. B. The same seen from behind.

ABDUCTION FRACTURES (SECOND DEGREE) Three ways in which the talus may be displaced outwards. C. Fibula fracture. Torn medial ligament. D Fibula fracture. Avulsion of medial malleolus. E. Fibula fracture. Diastasis of tibio-fibular ligament.

ADDUCTION FRACTURE. F The medial malleolus is sheared off obliquely and the talus is displaced inwards.

POSTERIOR-MARGINAL FRACTURE (THIRD DEGREE). G The talus is displaced backwards.

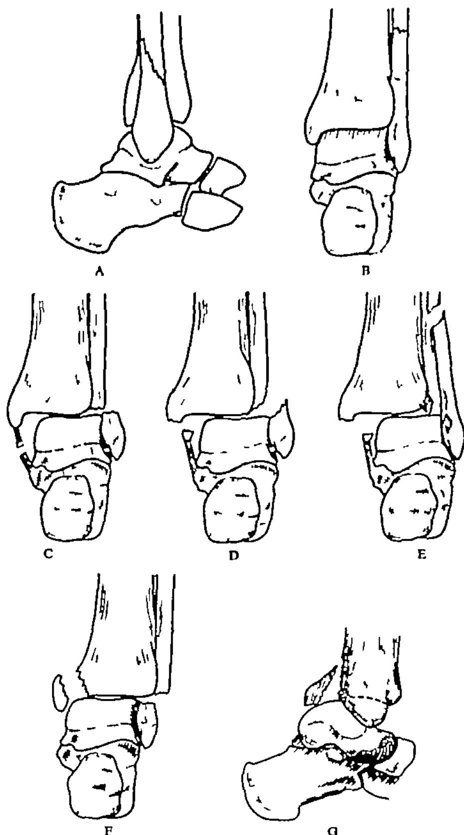


FIG 16 46. VARIOUS FORMS OF FRACTURE AND FRACTURE DISLOCATION IN THE REGION OF THE ANKLE JOINT

radiographs do not show slight separation of the bones. Widening of the gap between fibula and tibia can be demonstrated in a film taken with the leg rolled 60 degrees inwards. The instability is best demonstrated when the patient is anæsthetized and the foot held in forced abduction while the film is exposed.

A severe degree of diastasis may occur together with a fracture high in the fibular shaft. The talus may then lie between the tibia and fibula. This type is known as a Dupuytren's fracture-dislocation (Fig. 16 45)



FIG. 16 47 EXTERNAL ROTATION FRACTURE OF THE ANKLE.
The fibula is fractured obliquely and the medial malleolus is detached.

External Rotation Fracture. The foot is rotated outwards, imparting a torsional strain on the fibula. The bone breaks obliquely The fracture line starts about 3 inches (7 5 cm) above the malleolus and runs downwards and forwards. It may be almost invisible in the antero-posterior skiagram but clearly seen in the lateral view (Fig. 16 47) The tibiofibular mortice remains intact and there is no displacement of the talus. On examination, there will be swelling and tenderness over the lower shaft of the fibula but no deformity of the ankle.

Treatment No reduction is necessary Firm elastoplast strapping, or a light below-knee walking plaster should be applied for six weeks.

Abduction Fracture. The foot is forcibly everted. An element of external rotation is also present. Damage is caused on both sides of the ankle joint. The medial ligament is torn or alternatively the tip of the medial malleolus is avulsed (Fig. 16 48). The lower end of the fibula is fractured or the tibio-



FIG. 16 48 ABDUCTION FRACTURE OF THE ANKLE

In addition to the fibular fracture there is a fracture of the medial malleolus, and diastasis of tibio-fibular joint.



FIG. 16 49 FRACTURE DISLOCATION OF ANKLE WITH DIASTASIS OF TIBIO-FIBULAR JOINT

The medial malleolus and tibio-fibular joint have been stabilized by screws and anatomical reduction obtained.



FIG 16 50 ABDUCTION FRACTURE OF THE ANKLE.

In addition to a fibular fracture there is a rupture of the medial ligament with lateral displacement of the talus.

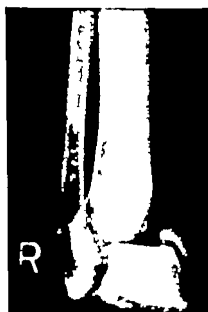


FIG. 16 51 ADDUCTION FRACTURE OF THE ANKLE.



FIG 16 52. POSTERIOR MARGINAL FRACTURE OF THE ANKLE.
The talus is dislocated backwards (third degree type).



FIG. 16 53 UNREDUCED FRACTURE-DISLOCATION OF THE ANKLE.

fibular ligament torn (diastasis). The talus may be tilted or displaced outwards (Fig. 16 50) In addition there may be a *posterior marginal fracture* of the tibia, which allows backward displacement of the talus (Fig. 16 52).

It is customary to classify these displacements in *degrees* first degree being a fracture of the fibula with no displacement of the talus second degree, when there is lateral displacement and third degree, when the displacement is both posterior and lateral (Fig. 16 53)

Adduction Fracture. These are inversion injuries. The talus is forced against the medial malleolus which shears off obliquely across its base (Fig. 16 51) There may be no displacement. If the lateral malleolus is fractured at the level of the ankle joint, the talus may be displaced inwards. This injury may also be combined with backward displacement, when the posterior margin of the tibia is fractured

The rare *bimalleolar fracture* is a variation in which both malleoli are fractured transversely at the level of the ankle joint. Displacement of the talus may be great, and the fracture is sometimes compound.

The term " Pott's " fracture is applied loosely to abduction fractures, and " Wagstaffe's " fracture to adduction fractures. Such nomenclature is of historic interest, but leads to confusion and is better avoided.

Treatment of Fracture-dislocation of the Ankle. *Manipulative Reduction.* The surgeon cannot exercise too much care in the reduction of the deformity caused by these fractures. The following points must be noted (*a*) the foot must be at right angles to the leg, and with this object in view reduction must be conducted with the knee bent so as to relax the tendo Achillis (*b*) the contour of the foot must look normal both in the anterior and lateral views (*c*) lateral displacement and torsion must also be corrected and this is secured when the inner surface of the great toe, the medial malleolus, and the inner

edge of the patella are in the same plane It is well, however to compare the foot with its fellow (*d*) anæsthesia must give complete muscle relaxation so that manipulation, application of plaster and control radiography can be carried out in an unhurried manner (*e*) radiography in both antero-posterior and lateral planes is essential and should be carried out while the patient is still anæsthetized so that another reduction may be attempted if the position is not perfect. The position of the talus in the grasp of the tibiofibular mortice should be anatomical

In reducing these fractures, therefore the knee must be flexed over the end of the operating table The surgeon should sit, taking the foot in his lap



FIG 16 54 WALKING PLASTER WITH ROCKER.

This position is comfortable for the operator and gives perfect control over the ankle joint. Palpation will determine when a fractured malleolus is in normal position

Reduction having been obtained, fixation is best secured by means of a plaster-cast extending from the tip of the toes to a point just below the knee-joint. The foot should be at right angles to the tibia and the fore-part of the foot " square " with the ground, as in walking.

Plaster Fixation If unpadded casts are used after manipulation the cast must be split Post-operative casts should always be padded. The foot should be kept elevated for a few days. Crutches may then be allowed. After two or three weeks, swelling will have subsided and the cast may become loose. A new cast should be applied and the reduction checked by radiography A rocker may then be applied and the patient allowed to walk in the plaster (Fig. 16 54). Fixation must be continued for ten to twelve weeks.

When the plaster is removed a firm elastic support is substituted to control œdema which will only finally disappear after several weeks of activity Massage is unnecessary but active exercises should be encouraged. With abduction fractures wedging of the shoe heel on the inner side (½ inch 1 cm) is advisable, or rarely an outside below knee iron and T strap may be worn for a few months.

Operative Reduction. Open reduction and fixation is indicated when reposition by manipulation is not perfect. Soft tissue may be found between the fragments and this must be removed The medial malleolus is fixed to the tibia by an oblique screw or nail

When the talus is displaced outwards, the reduction may be stabilized by repair of the torn medial ligament. Additional security may be obtained by a long screw inserted between fibula and tibia (Fig. 16 49).

Posterior marginal fractures of the tibia can often be reduced satisfactorily by manipulation The displaced fragment is brought down into position when the talus is lifted forward and the foot brought up to a right angle. Should manipulation fail open reduction may be possible through a posterolateral incision

Unreduced fracture-dislocations of long standing result in a painful ankle due to osteo-arthritis. Pain may be relieved and good function obtained by arthrodesis of the ankle joint.

Injuries of the Talus

These may be considered under five headings

Avulsion Fracture. This occurs at the site of ligamentous or capsular attachment and constitutes one form of sprained ankle.

Fracture of the Neck of the Talus. This is a rare injury caused by forced



FIG. 16 55 FRACTURE OF THE NECK OF THE TALUS. The body of the bone is rotated through 180

dorsiflexion of the foot as may occur in an air crash when the pilot's foot is resting on the rudder bar It is occasionally seen in children and happens for instance when the child's foot comes in contact with a rigid object when on a swing (Fig. 16 55)

Fracture of the Neck with Dislocation of the Subtaloid Joint This is a more common injury

Dislocation of the Talus. Rarely a pure dislocation of the bone from the ankle and subtaloid joints is encountered *The talus has a poor blood supply* due to the fact that it has no muscle attachments Therefore severe injuries to the bone are liable to be followed by avascular necrosis

Treatment Undisplaced fractures need immobilization in plaster with the foot at right angles.

Fracture-dislocations are dorsiflexion injuries. Reduction must be attempted with the foot in full plantar flexion. Skeletal traction on the calcaneum may be necessary before the bones can be manipulated into position. The foot is immobilized in plantar flexion being gradually brought up to 90 at successive plaster changes. Open reduction may be required for irreducible dislocations or arthrodesis for late painful arthritis.

Subtaloid Dislocation. This term means a displacement of all the bones of the foot from below the talus, which retains its normal position between the malleoli It is a rare injury Treatment consists in reduction by manipulation under anæsthesia which is sometimes readily accomplished but may be a matter of the greatest difficulty

Fractures of the Calcaneum

Fractures of this bone may be considered under two headings

Fractures of Processes. These include fractures of the anterior process, posterior process or the sustentaculum tali.

Crush Fracture of the Body Crush or compression fractures are the result of a fall from a height on to the heel. Other injuries may be present and it is well to remember to examine the spine, because compression fracture of a vertebral body may occur from the same type of injury A similar association was found during the late war when a mine exploded, and the deck of a ship transmitted a sudden blow to the heels

While many varieties of fracture are described it may be sufficient for the student to recognize three main types. The fact of most importance is whether or not the subtaloid joint has also been injured The three types are (*a*) fracture of the body with no joint injury (*b*) fracture of the body with minimal joint injury and (*c*) comminuted fracture with severe joint injury

Deformity On examination little deformity will be seen but the bone may feel broadened when grasped between finger and thumb There will be much swelling and pain. A patient who has fallen on to his heel with subsequent pain and swelling almost certainly has a fracture of the calcaneum.

Radiography will reveal the type of deformity present and it is important that both lateral and axial views be taken In the normal lateral skiagram it will be seen that the posterior half of the bone meets the anterior half at an angle of about 30° If the bone is divided into two halves transversely the pull of the Achilles tendon will reduce this angle and the bone will become flattened The tendon will be relaxed and its pull weakened (Fig. 16 56)

Damage to the subtaloid joint results in arthritis, loss of inversion of the heel, and pain. The period of disability following this injury is great, and

many men never return to their former occupation. Further disability is produced by the considerable hæmatoma and subsequent fibrosis which develops in the sole of the foot and around the midtarsal joints.

Treatment The patient is put to bed with the foot elevated Swelling may further be reduced by firm bandaging.

When the subtaloid joint is intact, or the injury is minimal, a plaster cast is applied when the swelling has subsided, and the patient allowed to get about on crutches, and later in a walking plaster when pain permits. It is removed in six weeks. Subsequent disability is slight. When there is broadening of the bone, this should be corrected by the application of a clamp, before the cast is applied



A B

FIG. 16 56. FRACTURE OF THE CALCANEUM.

A. There is severe comminution with involvement of the subtaloid joint and loss of normal contour B Antero-posterior view showing broadening of the bone.

Severe joint injury is always followed by considerable disability Loss of the normal contour of the bone may be corrected by Steinmann pin traction through the posterior half of the bone The functional result, however is often disappointing and it is better to ignore the deformity and to treat the foot by elevation and early movements No weight bearing is allowed for three months, but the patient may be allowed on crutches within a few weeks provided swelling is controlled by elastoplast or plaster of Paris. Subsequent painful arthritis may necessitate an arthrodesis of the subtaloid joint.

In selected cases this operation may be performed as a primary procedure about a week after the initial injury Much time may thus be saved

Fractures of the Forefoot

Tarsal Fractures. Fracture of the navicular or cuboid bones are rare and are usually seen in connection with a midtarsal dislocation. This must be reduced by manipulation and a walking plaster applied for eight to ten weeks. Later pain may require an operation for fusion of the midtarsal joints.

Metatarsal Fractures. *Fracture of the Base of the Fifth Metatarsal.*

Avulsion of the base of the fifth metatarsal is caused by sudden inversion of the foot and is a common sports accident. The peroneus brevis tendon is responsible for the fracture. The injury is treated by immobilization of the foot in a walking plaster for two weeks, followed by elastoplast strapping until all pain has disappeared. Fibrous union may result but with no permanent disability.

"March" Fractures. Fatigue or "march" fractures are occasionally seen in the necks of the second and third metatarsals, usually in young people who are doing strenuous exercise or standing for long hours. An abnormally short first metatarsal may predispose to the condition. The pain felt is of gradual onset and it is often several weeks before the patient seeks advice. A skiagram reveals a spindle-shaped mass of callus but the actual fracture line may not be visible. The condition is referred to in Chapter 13 (Fig. 13.2).

Treatment is, as for other fractures, by immobilization in a well moulded plaster for a few weeks, but occasionally a metatarsal pad and strapping will suffice.

Fractures of the Metatarsal Necks. Fractures of the metatarsal necks may cause disability when displaced. Reduction may be effected by traction by means of pulp pins inserted through the toes. Continuous traction may be provided by attaching these pins to a wire hoop incorporated in the plaster which must extend to the ends of the toes. Immobilization should be continued for six weeks.

Fractures of the Phalanges. These common injuries are caused by dropping a weight on the toes. The skin is split and a subungual hæmatoma develops. The fracture is comminuted but well supported by the soft tissues, and no splint is necessary. The wound is treated on general lines, covered with tulle gras or a flavine and paraffin dressing and a cap of gauze soaked in collodion is added for protection. The patient can walk in a sandal or soft shoe and can often return to work in a few days.

Chapter 17

INFECTIVE DISEASES OF BONES AND JOINTS

General Considerations

Bones may be conveniently divided into the long, the short, and the flat, each of these consisting of compact and cancellous tissue In the short bones there is a thin layer of compact tissue surrounding a cancellous central mass the meshes of which are filled with medullary fat and connective tissue In the flat bones the compact tissue forms two limiting plates, separated by a layer of cancellous tissue (known in the skull as the diploë). In long bones the shaft consists of a tube of compact structure, surrounding a space which is normally filled with medulla, and known as the medullary canal at each end it gradually merges into a larger mass of loose cancellous tissue, the interstices of which are similarly packed with vascular fatty medulla, which performs the function not only of maintaining the nutrition of the bone, but also of blood formation Prolongations from the medulla extend into the Haversian canals, and are thence continuous with the periosteum so that the mineral skeleton has incorporated within it a vascular fibrocellular mass which permeates the whole structure

The *vascular supply* of a bone is derived (*a*) from the nutrient artery which passes into the medullary space and there breaks up into branches which ramify through the whole of the medullary tissue and thence extend into the Haversian canals and (*b*) from the periosteum, an exceedingly vascular ensheathing membrane from which small vessels pass perpendicularly into the Haversian canals, and establish a communication between the two systems. These latter vessels are especially numerous and large, close to the epiphyses. Large veins occur in the medullary and cancellous interior and are frequently thrombosed as a result of inflammation if the thrombus becomes infected, and disseminated by the blood stream, pyæmia is very likely to ensue.

The *growth* of bone manifests itself in three different directions (*a*) It increases in length from the shaft side of the epiphyseal cartilage (or metaphysis) the epiphysis itself growing but little. In the upper limb the chief increase in length occurs at the shoulder and wrist, while in the leg it is mainly evident on either side of the knee joint, and this in spite of the fact that the nutrient arteries are directed away from these points. (*b*) Increase in breadth is produced by new formation under the periosteum (*c*) A bone increases in density by a new deposit of osseous tissue around the Haversian canals and cancellous spaces

Finally it must be pointed out that the development and growth of the skeleton are largely dependent on the healthy activity of the endocrine glands the pituitary thyroid and adrenal having considerable influence. Adenoma or hyperplasia of the parathyroid glands results in generalized osteitis fibrosa, a disease which may be arrested by the removal of the affected parathyroid. Moreover a balanced food-supply and the presence of sunlight or its equivalent, together with the provision of certain mineral salts, are necessary if healthy bone is to be laid down or maintained

Effect of Disease upon Skeletal Growth Many general diseases of childhood are associated with deficient skeletal growth In particular may be mentioned renal dwarfism tuberculosis of the spine cœliac disease and congenital affections of the heart. Local factors may affect the growth of the epiphyseal cartilage Premature closure of the epiphyseal line may result from prolonged immobilization of the limb or from local trauma or disease Local inflammatory hyperæmia may stimulate growth Thus a leg may be appreciably lengthened after an attack of acute osteomyelitis of the lower end of the femur or after prolonged hyperæmia from tuberculosis of the knee joint

Diseases of Joints. The anatomy of individual joints varies considerably but it will be sufficient here to consider the main features of the diarthrodial joint. The ends of the bones which form the joint consist of condyles covered with articular cartilage In the young, the condyles are in fact epiphyses and are separated from the shaft of the bone by the epiphyseal cartilage from which growth takes place In certain joints (*e g* the hip) the epiphyseal cartilage is contained within the joint capsule so that infection in this region is likely to spread to the joint cavity In other joints (*e g* the knee) the epiphyseal cartilage is outside the capsule and spread of infection to the joint is unlikely

The stability of the joint depends upon the capsule strengthened by ligaments and when these structures become softened and stretched by inflammation or by distension of the joint with fluid partial or complete dislocation may occur This is spoken of as a pathological subluxation or luxation. The joint is lined by synovial membrane except over the articular cartilage, and the synovial secretion is responsible for lubrication When the synovial membrane is irritated by trauma or infection, an excessive secretion results in an effusion into the joint.

Inflammation of Joints This may be caused by trauma infection or constitutional diseases such as gout or rheumatoid arthritis. The inflammation may be chiefly limited to the synovial membrane, constituting *synovitis* or may spread to articular cartilage ligaments and bone, constituting an *arthritis* There is however no absolute line of demarcation between these two conditions.

In considering diseases of the spine, it must be remembered that the small posterior intervertebral joints are diarthrodial but the junction between the vertebral bodies consists of fibrocartilaginous plates or intervertebral discs. These joints are called symphyses (*e.g* symphysis pubis)

Effusion. An effusion usually consists of synovial fluid. Infection, however may cause the joint to be distended with pus (*pyarthrosis*) or trauma may result in distension with blood (*hæmarthrosis*) The physical signs depend upon the anatomy of the joint concerned In general, there will be swelling, with some limitation of movement, and the joint will feel hot. The characters of effusions into particular joints are described on page 437

Inflammation of Bone

Much needless confusion has arisen in connection with this subject owing to the undoubted difficulty of understanding the pathological phenomena, but also largely due to careless and contradictory nomenclature The following considerations may assist in making the subject more clear

Osteitis. All inflammatory affections of bony tissue might rightly be termed *osteitis* but when the medullary cavity of a long bone is particularly affected the term *osteomyelitis* is substituted as also sometimes when masses of cancellous tissue, as in the calcaneum, or sheets of it, as in the diploë, become the seat of acute inflammation The term *periostitis* applies to the ensheathing membrane the vascular connection between it and the underlying bone explains why inflammation of this structure is always associated with a superficial or deep osteitis, and why in an acute infective inflammation of the medulla of a long bone, the periosteum is also liable to be affected.

Epiphysitis This term is applied to inflammatory affections of an epiphysis, which it must always be remembered has a vascular supply distinct from that of the diaphysis. As will be explained later acute pyococcal affections do not often commence in the epiphysis, although it may be involved secondarily to an inflammation commencing in the neighbouring shaft chronic diseases, *e.g* tuberculosis and syphilis, do however involve epiphyses more frequently though they are not limited to them.

In all inflammatory affections of bone the vascular structures are primarily involved the mineral element is only secondarily affected. The resulting phenomena hyperæmia, exudation and tissue change, differ in no wise from those seen elsewhere save that the effects are modified by the limited space in which the vessels lie, and the resisting character of the surrounding bony tissue Hence any acute inflammation involving compact bone, associated with vascular engorgement and rapid exudation, leads to necrosis from thrombosis, due to increased pressure within the unyielding bony canals. If however the bone involved is cancellous, or the process *subacute* so that the tissue-liquefying properties of the exudation and the tissue-absorbing activity of the leucocytes can come into play then osteoporosis or rarefaction of the bone follows, a condition sometimes termed *caries* Not infrequently however some of the more resistant fragments of the bony cancelli escape absorption and die *en bloc* constituting a condition of *cariosnecrosis* On the other hand if the inflammation is *chronic* and due to causes other than tubercle bacillus, then new bone formation occurs, and osteosclerosis, or condensation, is most likely to result. Tuberculosis in bones as elsewhere, causes primary rarefaction of the tissue attacked though sclerosis may be associated with the process of healing.

Results of Inflammation. It must always be remembered that necrosis, caries, and sclerosis of bone are results of inflammation, and not pathological processes or distinct disease Each of them may arise from many distinct causes.

Necrosis This may result from the following conditions (*a*) acute localized suppurative periostitis, the sequestrum or dead mass being then simply a superficial plate or flake of the compact bone (Fig. 17 1) the process by which it is cast off being described as "exfoliation" (*b*) from acute infective osteomyelitis, the sequestrum often involving the whole thickness of the bone, and invading more or less of the length of the diaphysis, if the condition is not early and efficiently treated (Fig. 17 5) (*c*) from acute or subacute infective osteitis of cancellous bone the sequestra being small spiculated fragments of the bony cancelli, which have escaped absorption (*d*) from tuberculous disease of cancellous tissue, the sequestrum being light and porous, often surrounded by caseous material, and rarely separated completely from the adjacent parts (*e*) from syphilitic disease of cancellous

or compact tissue usually resulting from excessive sclerosis, or gummatous disease of the periosteum which has become septic (Fig. 17 46) (*f*) from the action of local irritants, *e.g* mercury or phosphorus gaining access to a tooth socket (*g*) occasionally from endarteritis as in senile gangrene and (*h*) a variety described by Sir James Paget under the name of "quiet necrosis," occurs as a result of direct injury the sequestrum separating without suppuration it is one of the causes of loose bodies in joints, especially the knee and may be the cause of osteochondritis dissecans

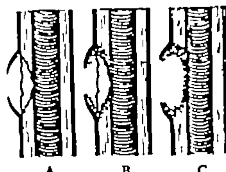


FIG. 17 1 SUPERFICIAL NECROSIS RESULTING FROM A LOCALIZED PERIOSTITIS.
A. represents the necrosed tissue lying in continuity with the surrounding living bone the periosteum is stripped up from it, and has an opening through which the pus has been discharged. B. shows a later stage in which the sequestrum is being separated by a process of rarefying osteitis in the immediately contiguous living bone, while an involucrum, or sheath of new bone, is formed from the under surface of the periosteum a cloacal aperture remains in the involucrum for the escape of discharges. C. shows the condition of affairs after the sequestrum has been removed.

The presence of dead bone in a limb may be suspected when one or more sinuses are present, discharging pus or serum according to circumstances, with puffy granulations, pouting round the opening, and the under lying bone thick and enlarged. A probe passed down the sinus can usually be made to strike against the sequestrum, perhaps after passing through a casing of new bone, and its fixity or freedom may be demonstrated in this manner

Caries This is sometimes called *osteoporosis* or *rarefaction* and is characterized by a soft and spongy state of the bone, which, if it can be reached, readily breaks down on pressure with a probe. It may result from the following conditions (*a*) acute or subacute infective inflammation of cancellous tissue (*b*) tuberculous affections of the cancellous tissue or periosteum (*c*) syphilitic disease of the medulla or of the under surface of the periosteum. The spongy vascular condition of the bone ends during the early stages of repair of a fracture is practically identical with this condition.

Pathologically it is characterized by the replacement of the medulla by granulation tissue, which usually contains some large multinucleated cells, or osteoclasts, and these seem to be closely connected with the removal of the bone. The cancellous tissue becomes hollowed out to accommodate these granulations, and the osteoclasts are usually found occupying shallow depressions known as "Howship s lacunæ. In tuberculous and syphilitic lesions the bone corpuscles often undergo fatty degeneration.

Caries may occur with or without suppuration (*C suppurativa* or *sicca*) sometimes the development of granulation tissue is excessive, as when it

fungates into a joint (*C fungosa*) Not infrequently it is associated with necrosis, constituting a condition of *carionecrosis* (or *C necrotica*), as in infective inflammation of cancellous bone, minute spiculated sequestra being found in the discharge, whilst in tuberculous osteitis sequestra of larger size often occur In fact, caries and necrosis bear much the same relation to one another as ulceration and gangrene of the soft tissues.

After recovery from caries, a condition of sclerosis usually follows, sometimes with loss of substance and deformity

Sclerosis This is invariably the result of some chronic inflammatory affection, e g (*a*) chronic periostitis, whether infective or syphilitic (*b*) chronic osteomyelitis, infective, tuberculous, or syphilitic or (*c*) chronic osteitis of the compact bone which is always secondary to one of the former In all cases the condition is due to a slow formation of new bone within the Haversian canals or cancellous spaces, thus diminishing their lumen in syphilis this may progress to such an extent as to lead to their total occlusion, and even to localized necrosis from lack of blood-supply especially when sepsis has occurred. In tuberculous bones the sclerosed tissue is always at some distance from the focus of destruction and may be looked on as Nature s attempt to limit the spread of the disease it forms also the final tissue or bone-scar in the process of repair when a cure has been obtained by natural or surgical means

Acute Inflammation of Bone

Bone may be infected in three ways (*a*) Direct infection, (i) through an open wound, (ii) from neighbouring soft tissues and (*b*) Blood Stream infection.

When the infection is direct, it may be limited to the periosteum and compact bone (*periostitis*) when blood borne, both cortex and medulla are involved (*osteitis* or *osteomyelitis*)

Direct Infection. Examples of this type are wounds of the soft tissues and periosteum alveolar abscess leading to osteomyelitis of the jaw pulp infections of the fingers, followed by osteomyelitis of the phalanx frontal or mastoid sinusitis spreading to the bone of the cranial vault or mastoid process open fractures and amputation stumps

Blood Stream Infection It is not always possible to find the source of infection which is usually due to the *Staphylococcus aureus* The skin should be examined for pimples, impetigo and boils. Nasopharyngeal infection is another possible source

Acute Local Periostitis. This may result from direct trauma or by spread of infection from neighbouring structures (*e g* alveolar abscess)

Pathology The periosteum becomes hyperæmic and swollen If resolution does not take place, suppuration and superficial necrosis of bone may occur Sometimes the inflammation becomes chronic, with persistent thickening caused by the laying down of subperiosteal new bone The pathological changes associated with infective periostitis and osteomyelitis will be considered together

Open Fractures. Infection occurs in an open fracture, because wound toilet has been incomplete or delayed too long. Heavy soiling of the wound and delay in treatment may make infection inevitable The organisms may be mixed, coming from the skin and clothing of the patient, or from road

dust and soil and carried into the wound by a missile or other penetrating object Reinfection may occur when the wound is dressed from air borne organisms, ward blankets, droplet infection and other sources Cultures often reveal staphylococci streptococci and organisms of the coli group together with occasional anaerobes.

If there is free drainage, the bone infection remains localized with suppuration, necrosis and sequestra formation Healing of the fracture will not take place until the acute inflammation has subsided Sinuses may persist until all sequestra have been discharged or removed The time required for union will be considerably delayed and in fact union by bone may never occur

Small penetrating wounds do not allow adequate drainage from the infected fracture and it is usually the deep fascia which is the chief barrier In dealing with this type of wound it is necessary to open up the deep fascia widely by a criss-cross incision or to excise a portion. If drainage is inadequate, blood stream infection may occur

Clinical Signs There will be the usual signs of acute inflammation superimposed upon those of a fracture The constitutional disturbance is usually slight, with mild pyrexia and malaise Locally there will be increased heat and swelling, with a purulent discharge and with enlargement of the lymph nodes draining the limb Severe malaise high pyrexia and rigors will indicate the onset of septicæmia or pyæmia.

Treatment The aim is to provide drainage and immobilize the limb The dressing should consist of a light packing of Vaseline Gauze to keep the soft tissues apart. Immobilization may be on a skeleton splint or in plaster of Paris, in which a large window is cut. Sometimes continuous traction will be necessary Antibiotics are given in adequate doses and blood transfusion when indicated Sequestra should be removed as soon as they separate. After the inflammation has subsided prolonged immobilization is essential to secure bone union Bone grafting carries a high risk of re activating the latent bone infection and in any case it is unwise to attempt it until at least a year after the wound has healed. The question of amputation may arise, either as a life-saving measure, during the acute phase or later as an alternative to a long period of immobilization, with the uncertainty of useful function as a final outcome.

Amputation Stumps. Bone infection is likely after amputations for severe trauma or for infective gangrene. The risk of osteomyelitis can be minimized by delayed suture. At the completion of the amputation the flaps are left wide open and the wound dressed with Vaseline Gauze. If after a few days the wound is clean, it may be closed. The local signs of infection do not differ from those of an infected fracture. Sequestra when formed are often tubular or ring-shaped After healing, the skin is likely to be adherent to the under lying bone and reamputation at a higher level will be required.

Acute Infective Osteomyelitis (Acute Osteitis)

This disease usually occurs in children, and in boys more often than in girls (4 3) and not infrequently follows one of the exanthemata, *e.g* measles or scarlet fever It is usually seen before puberty The onset may be insidious but occasionally rigors and profound toxæmia may accompany the bacillæmic stage. In this case death may follow within a few days. In recent times the disease has become much less severe and less frequent, due probably to an

improvement in general health and hygiene The advent of antibiotics has done much to mitigate the more serious effects

When the disease occurs in adults, the constitutional disturbance is usually slight and the local lesion is subacute rather than acute in type.

Pathology The patient may be debilitated with low powers of resistance. Sometimes a septic focus may be found on the skin or in the mouth or nasopharynx. More often, however none is found The causative organism is *Staphylococcus aureus* in 95 per cent. of cases but pneumococci and streptococci are occasionally found

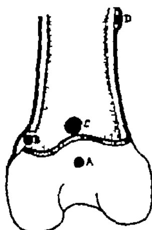


FIG. 17 2. PRIMARY FOCI OF OSTEOMYELITIS.

(A) In the epiphysis (B) under the periosteum of the metaphysis, (C) in the metaphysis, the usual site (D) under the periosteum along the shaft.

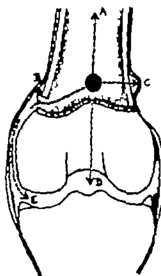


FIG 17 3 THE SPREAD OF OSTEOMYELITIS.

If the primary focus is in the metaphysis, spread may occur down the medulla (A), through the compact tissue near the diaphyseal cartilage under the periosteum (B), or into the joint (E), through the compact tissue of the diaphysis to form a subperiosteal abscess (C), or directly through the epiphysis into the joint (D)

The first factor necessary for an attack of osteomyelitis is therefore the presence of organisms in the blood stream This is called bacillæmia, and the blood culture is positive in about 50 per cent. of cases. Something else *must decide the site of bone infection.* Osteomyelitis is commonly found in the long bones, and the lower limb is affected more often than the upper The disease starts in that part of the diaphysis which is adjacent to the epiphyseal cartilage and which is called the metaphysis

It is thought that slight trauma or the pull of large muscles attached in the region of the epiphysis, may cause a small hæmatoma or in some way lower the local resistance to infection. Organisms in the blood stream then find a suitable nidus in which to grow Another factor is that the blood vessels on the metaphyseal side of the epiphyseal cartilage are end-arteries and this may determine the lodgement of organisms or infected emboli.

Site of Bone Infection The disease starts in the metaphysis (Fig. 17 2) either as a subperiosteal focus, B and D or as a medullary focus C Primary epiphyseal infection, A is unusual.

The extent of the disease will depend upon the exact site of infection the virulence of the organisms and the resistance of the patient. Treatment, whether instituted early or late, and the method employed will also influence the course of the disease.

Periosteal Focus The infecting organisms cause the usual changes associated with acute inflammation The exudate rapidly becomes infected and a subperiosteal abscess is formed The periosteum is stripped off for a varying distance and the underlying bone is deprived of its blood supply



FIG. 17 4 ACUTE OSTEOMYELITIS OF THE TIBIA.
The focus is in the metaphysis and is subcortical.

owing to thrombosis of the blood vessels (Fig. 17 4) Spread to the neighbouring joint is dependent upon the local anatomy In the case of the knee it is unusual, because the metaphysis is outside the attachment of the joint capsule. In the case of the hip however the *metaphysis is within the capsule* of the joint and the subperiosteal abscess must infect the hip joint when it bursts. Hence the common cause of suppurative arthritis of the hip is a subperiosteal abscess of the neck of the femur

As a result of local ischemia, necrosis of the underlying compact bone may take place and a flake of dead bone or sequestrum may form (Fig. 17 5) The raised periosteum will form a sheath of new bone which is called the involucrum (Fig. 17 6) The dead bone or sequestrum lies in a bed of pus and granulation tissue which will in time separate it from the living bone. The pus escapes through holes or cloacæ in the involucrum and forms a soft tissue abscess, which eventually finds its way to the surface. When it finally

bursts through the skin a sinus is formed, leading down to the dead bone. Healing will not take place until the sequestrum is discharged or removed. Permanent thickening of the bone will result from the presence of the involucrum which becomes incorporated with the compact bone.

This type of periostitis sometimes affects the posterior aspect of the lower end of the femur. The general signs are those of malaise and pyrexia. There are local signs of acute inflammation with pain and tenderness and



FIG. 17 5 OSTEOMYELITIS OF THE TIBIA. (*King's College Hospital Museum.*)
The sequestrum, composed of the diaphysis, lies in a cavity surrounded by new bone, from which discharging sinuses open on to the skin. *The knee-joint is distended with fluid.*

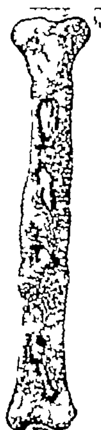


FIG 17 6. NECROSIS FOLLOWING ACUTE OSTEOMYELITIS. (*Royal College of Surgeons Museum.*)
The irregular new bone of the involucrum is well seen and within it portions of the sequestrum.

swelling. Walking will be difficult and there may be an effusion into the neighbouring joint which is fixed by muscle spasm. Later the skin becomes œdematous, hot and red, and an abscess forms. When it bursts, or is opened, bare bone may be seen in the depth of the wound. The time required for separation of the sequestrum may vary from a few weeks to several months, depending on the site and density of the bone involved. It may be seen in a

radiograph as a dense shadow compared with the hyperæmic and rarefied living bone surrounding it. Its mobility or otherwise may be determined by a probe inserted into the sinus. It should not be removed until quite free because it is impossible to tell where the line of separation will eventually take place.

Medullary Focus. The primary focus may also be in the medulla (Fig. 17 3 A). Spread of infection may take place outwards so that a secondary subperiosteal abscess is formed. In addition the spread may be along the medullary cavity. The infection rarely passes through the epiphyseal cartilage into the epiphysis. When medullary infection occurs, the periosteum becomes infected sooner or later and it may be difficult to decide where, in fact, the primary focus lay (Fig. 17 7).



FIG. 17 7. ACUTE OSTEOMYELITIS OF THE RADIUS.
The sequestrum consists of the whole of the diaphysis.

The outcome of the infection depends upon several variable factors. Of these, the virulence of the organism and its sensitivity to antibiotics are probably the most important. The natural resistance of the patient, and the time at which treatment is started are also of importance, although the latter seems to have less influence than might be supposed.

Osteomyelitis of Flat Bones. These may include the diploë of skull, scapula and innominate bones. Caries may result in small spiculated sequestra. The cancellous bone becomes filled with pus and owing to the abundant veins, pyæmia is likely. In the case of the diploë an extradural abscess may form and the infection may spread to the meninges and brain.

Termination. Acute osteomyelitis may terminate in several ways.

Resolution. It is difficult to be certain how often resolution occurs spontaneously as the diagnosis may be uncertain in the early stage of the disease. There is no doubt that when antibiotic treatment is started early resolution can take place. Indeed this should be the aim of treatment.

Chronic Osteomyelitis. When, because of an insensitive organism or delayed treatment, widespread bone infection has taken place, the acute stage passes into the stage of chronic osteomyelitis.

A large portion of compact bone, or the whole diameter of the shaft may die. This area becomes surrounded by an involucrum containing many cloacæ, discharging pus through skin sinuses. Removal of the sequestra may result in healing, but the living bone is the seat of latent infection (chronic osteitis) and recurrent " flares " are likely. Discharging sinuses and recurrent

flares may persist throughout life and may result in toxic absorption leading to amyloid disease of the liver spleen or kidneys. After many years, squamous celled carcinoma may form in the sinus tracks.

Brodie s chronic bone abscess which is a distinct entity and is not connected with acute osteomyelitis, is described later

Joint Infection The hip elbow and shoulder joints are likely to become infected when osteomyelitis occurs in the neighbouring metaphyses, because these structures are contained within the joint capsule. *Infection of the hip* is more common than that of other joints because osteomyelitis occurs more frequently in the lower limb The epiphysis may become detached and be shed as a sequestrum. Instability of the joint and shortening of the limb may result.

Death This may occur within forty-eight hours from septicæmia, or within a few weeks from pyæmia. This fulminating type of disease is now rarely seen, but was undoubtedly more common in the days before antibiotics. Amyloid disease from chronic sepsis is now a rarity

Clinical Features. The disease may start with a rigor followed by high fever This is followed after a few hours by severe pain in the limb, but the signs of the local inflammatory lesion may not be apparent for a day or two. Commonly the onset is less dramatic. The child is fretful and off his food. He complains of pain near a joint, and a diagnosis of trauma may be made. There is fever the temperature being 99 to 103 degrees with a furred tongue, malaise and local tenderness and swelling near a joint. This should suggest a diagnosis of acute osteomyelitis. The pain may be severe and the child will not walk.

Radiology will exclude fractures but is otherwise not helpful during the first week or ten days of the disease The earliest radiological signs are some local rarefaction of bone, together with new bone formation under the raised periosteum. Blood examination will show a raised white cell count, with a preponderance of polymorphonuclear leucocytes.

Differential Diagnosis. The following are the main conditions which may be confused with acute osteomyelitis

Cellulitis When cellulitis or an abscess in the soft tissues is suspected near the end of a long bone, the most likely diagnosis is osteomyelitis. Infection starting in the soft tissues tends to be more superficial, the skin is reddened at an early stage, and the constitutional symptoms are less marked.

Acute Infective Arthritis The joint may be the primary site of infection from the blood stream. The swelling and tenderness will be over the joint rather than near it. There will be signs of an effusion. Attempts at passive joint movement will produce intense pain and muscle spasm.

When any doubt exists the joint should be aspirated Naked eye and bacteriological examination of the fluid obtained will confirm the diagnosis.

Rheumatic Fever In this disease pyrexia, with multiple joint swellings and cardiac signs are typical. Difficulty in diagnosis between rheumatic fever and infective arthritis may arise when a single joint is affected. When doubt exists the joint should be aspirated and the fluid examined

Trauma There may be a history of slight trauma in many cases of osteomyelitis Separation of an epiphysis is unlikely unless the trauma has been severe The absence of pyrexia and malaise, together with radiological examination should make the diagnosis clear

Acute Anterior Poliomyelitis The onset of this disease may be accom-

panied by pain in the limbs, local tenderness and muscle spasm The symptoms may be widespread The development of paralysis may be delayed

Blood Diseases The subperiosteal hæmatomata of scurvy and purpura are painful and may be mistaken for subperiosteal abscesses.

Ewing's Sarcoma This is a rare tumour of bone which occurs in the middle of the shaft rather than at the end of a bone The swelling may be hot and tender and there may be some pyrexia On aspiration or incision the soft tumour substance has been mistaken for thick pus Radiology of the limb and histological examination of aspirated material or a piece removed for biopsy will establish the diagnosis.

Prognosis. The prognosis of acute osteomyelitis, while always serious is less grave than formerly Life may be threatened by septicæmia in the early stages, while amyloid disease may occur much later When resolution takes place, the function of the limb may be unimpaired, but the painful episodes which accompany the recurrent flares of chronic osteomyelitis together with discharging sinuses or the involvement of joints leading to ankylosis produce lifelong disability Extensive operations for the removal of sequestra or the opening up of bone cavities may be required In the most severe cases amputation may be the only solution.

Treatment. Treatment may be divided into general and local. General treatment consists of bed rest, fluids by mouth and mild aperients. A blood culture should be set up and the limb radiographed for future reference

Antibiotics In the early stages of the disease the infection may be brought under control by antibiotics alone, provided the staphylococcus is sensitive to the antibiotic used. In spite of the increase of insensitive strains of staphylococcus, penicillin remains the most useful antibiotic with which to start treatment. It must be given in large doses by intramuscular injection in order to maintain an adequate blood level Thus in a child of five years at least 500 000 units six hourly or the equivalent in long acting types of penicillin should be given. Pain and pyrexia may persist for a few days and the temperature will resolve by lysis. Penicillin should be continued for four to six weeks or until it can be demonstrated by marrow culture that sterilization has been accomplished. If there is no response after twenty four hours of penicillin therapy the antibiotic should be changed to tetra cycline or erythromycin Sensitivity tests of organisms obtained from blood culture may not be available for several days.

Operative Treatment The majority of cases of osteomyelitis do not come to hospital until there are well established local signs in the limb These will require surgery in addition to antibiotic treatment. The bone is exposed through a small incision with due regard to the proximity of the epiphysis and the neighbouring joint. When the periosteum is incised pus will probably be found. This may be sufficient to relieve tension but it is usually wise to drill a few ⅛ inch (3 mm.) holes through the cortical bone into the medulla. Often pus will be seen to well out, when this is done The wound is then closed by interrupted sutures in the skin only and the limb im mobilized on a plaster slab Primary healing is to be expected With this treatment there will be immediate relief of pain and the temperature will fall within a few hours.

When the acute symptoms have subsided the limb may be encased in a light plaster of Paris cast until healing of the soft tissues and bone has occurred. Antibiotics should be continued during this period.

Treatment of Chronic Osteomyelitis Persistent discharge indicates the presence of a sequestrum or a bone cavity Operation should be deferred until the sequestrum is free, which may be seen by serial radiography Under antibiotic cover the wound will require reopening to remove the sequestrum, or to "saucerize" bone cavities. Light packing with Vaseline Gauze will allow granulation to occur but where possible, bone cavities should be filled with muscle.

Recurrent abscess in later life may require drainage. Sometimes an extensive operation to open up bone cavities may be successful but often it fails and a sinus persists In these cases it may be better to accept the situation and to refrain from further attempts at cure

To summarize, therefore, the treatment of acute osteomyelitis is (*a*) Septicæmic stage before local lesion is well established antibiotic therapy (*b*) When local lesion can be identified antibiotics together with incision and bone drilling (*c*) Healing stage antibiotics and splinting to be continued at least four to six weeks.

Special Forms of Osteitis

Osteitis in the Newborn. Infection still remains an important cause of death or disability during the early weeks of life, in spite of the general reduction in infant mortality Umbilical or other foci of sepsis are responsible for the blood stream infection which is usually staphylococcal. Any bone may be affected but the maxilla and upper end of the femur are commonly involved.

Diagnosis Soft tissue infections in small babies are rare, so that swelling, tenderness and irritability on handling, should arouse suspicion of osteitis. There may be a relative lack of movement in one limb similar to the pseudo-paralysis of scurvy

Prognosis The disease is often mild, but occasionally metastatic abscesses may occur in the lungs, kidneys or other organs. When the upper femur is involved infection of the hip-joint is likely and this may lead to destruction of the joint with dislocation and permanent deformity

Treatment There are two essentials. (*a*) Early and adequate dosage with antibiotics, penicillin (50 000 units) and streptomycin (0 25 g.) and (*b*) the aspiration of pus. Immobilization of the limb is often impractical in a small baby Antibiotics should be continued for at least six weeks, at first by injection three hourly and later by mouth. Occasionally sequestra may need removal.

Brodie's Abscess. This is a chronic bone abscess which arises insidiously and is not the result of an attack of acute osteomyelitis, for which the term residual abscess may be reserved. This was originally described by Sir Benjamin Brodie as a chronic tuberculous abscess, but the majority are staphylococcal, although a few are tuberculous. Often, however the contents are sterile on culture

Symptoms and Signs These are usually mild and are confined to a deep seated ache near one end of the bone which is often the tibia. The ache is worse at night and when the limb is warm On examination some local thickening of the bone may be felt and the area is tender on pressure.

Radiological Diagnosis The diagnosis depends largely on the radiological findings. These are a central cystic area surrounded by sclerosed bone and in addition if the abscess is superficial, there may be some periosteal

new bone surrounding it (Fig 17 8) Such a radiological appearance suggests three possible diagnoses (a) A chronic staphylococcal abscess, (b) A healing tuberculous abscess, or (c) An osteoid osteoma (see p 514)

A solitary cyst of bone is never surrounded by sclerosed bone and there is no periosteal reaction

Treatment When symptoms are severe enough to warrant operative treatment, the bone should be opened, the contents of the abscess cavity removed with a curette and the cavity saucerized It may then be obliterated with a muscle flap and the wound closed

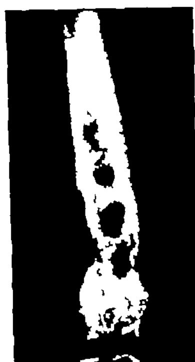


FIG. 17 8. CHRONIC STAPHYLOCOCCAL OSTEOMYELITIS OF THE FEMUR
The abscess cavities are well shown.

Sclerosing Non-suppurative Osteomyelitis. This is a rare type of chronic inflammation described by Garré and associated with aching and tenderness. The radiological picture is that of dense sclerosis together with periosteal bone reaction. The possiblity of bone sarcoma, syphilis or osteoid osteoma must be considered. Excision or decompression of the sclerotic area will usually cure the symptoms.

Typhoid Osteitis. Bone lesions are common in typhoid fever and usually occur during the early stages of convalescence The tibia and ribs are most often affected and in a large percentage of cases typhoid bacilli, with or without pyogenic cocci, will be found The osteitis starts either as a periostitis or osteomyelitis, subacute in character often improving temporarily and then relapsing it is curious to note how long the organisms may lie latent in the tissues before causing an abscess In time an abscess usually develops, together with some amount of necrosis or caries. Sometimes an abscess within the bone communicates through a small sinus with one beneath the periosteum, constituting a " collar-stud " abscess.

The treatment of the disease is by chloramphenicol or other antibiotics of the affected bone along the same lines as for other forms of osteomyelitis

Acute Arthritis

Acute inflammation of a joint may be caused by trauma or infection the latter may be non-suppurative or suppurative. The inflammatory changes may be confined mainly to the synovial membrane (*synovitis*) or extend to the articular cartilage or other structures (*arthritis*). These two conditions must overlap and are clinical rather than pathological terms They should not be regarded as entirely separate entities and it is often difficult to say at what stage the one passes into the other



FIG 17 9 SEROUS EFFUSION INTO THE LEFT KNEE JOINT
The suprapatellar pouch is distended.

Traumatic Synovitis or Arthritis. This may follow any injury to a joint. The injury may be a direct blow a sprain or wrench, a dislocation or a fracture involving the articular surface. Direct blows are likely to bruise the *synovial membrane, while sprains may cause a tear* in this structure as well as in ligaments Traumatic synovitis is studied most readily in the knee joint or ankle

Clinical Signs There is an effusion of synovial fluid or blood within the joint, which is swollen, warm and tender (*Fig. 17 9*) *Movement is* painful and limited by muscle spasm. Organization of blood clot may lead to adhesions which limit movement and cause recurrent attacks of pain, followed by effusion. Injury to a joint is always accompanied by rapid wasting of the muscles around it. Muscle wasting leads to instability joint strain and further effusion and thus a vicious circle of trauma–effusion–muscle wasting–instability–effusion is set up Early and effective treatment may prevent this, but if once established, the circle may be difficult to break.

Treatment The immediate treatment consists of rest, removal of fluid and restoration of muscle tone.

In severe cases rest should be achieved on a splint and in certain joints (*e g* hip or knee) may be combined *with light traction.* After a few days, active movement may be allowed within the limit of pain. A knee or ankle may be supported by a firm bandage. Weight bearing should be avoided

for a few days and the joint must be guarded from strain by strapping for at least three weeks

Rapid absorption of fluid is essential Large effusions should be aspirated and in the case of the knee or ankle a pressure bandage over cotton wool must be applied Persistent effusion suggests that the joint lesion is not healed or that instability from lax ligaments or weak muscles allows repeated strains to occur

Active muscle contractions, supplemented if necessary by electrical stimulation are started at once These must be continued many times daily *until all effusion has gone, and until full muscle tone is restored*

Effusions into Particular Joints. *Shoulder* The curvature of the shoulder is increased, and the deltoid expanded by a fluid swelling beneath it, which is especially noticeable at its anterior border along the bicipital groove, and sometimes posteriorly in the axilla a swelling may also be felt. These symptoms may be simulated by inflammation of the subdeltoid bursa but the latter condition is recognized by the absence of any axillary swelling, by its not encroaching on the anterior and posterior borders of the deltoid and by the fact that, although when the patient voluntarily moves his arm pain is produced yet when the surgeon gently manipulates it, so as to press the head of the bone against the glenoid cavity there may be none

Elbow The arm is maintained in a position of flexion and pronation the hollows on either side of the olecranon and tendon of the triceps are replaced by soft fluid swellings, the outer of which also extends down to and masks, the head of the radius there is usually a little swelling in front of the joint. It is readily distinguished from inflammation of the olecranon bursa by the fact that in the latter condition there is a central fluid prominence over the bone, while in the former the swellings are placed on either side of and above the bony projection.

Wrist The hand is in a condition of slight flexion, and there is a general fullness around the joint, most marked on the anterior and posterior aspects but also noticeable below the styloid processes. The tendons in their sheaths are lifted up back and front, and deep fluctuation may be detected beneath them. It is distinguished from a tenosynovitis in that the swelling is limited more or less to the joint line and does not extend up and down in the direction of the tendons there is also no limitation of movement of the fingers, and the characteristic crepitus of tenosynovitis is absent.

Hip Effusion cannot be easily detected by digital examination There may be a little fullness and tenderness in the groin, or in the gluteal region. The most characteristic feature, however is the position of flexion, abduction and eversion taken by the limb, while limitation of *movement is equally* marked

Knee When distended with fluid the knee presents a rounded outline, in which all the normal hollows, especially those on either side of the patella and ligamentum patellæ, have disappeared. There is also a swelling corresponding to the suprapatellar pouch, more marked on the inner than the outer side, and extending for 2 inches (5 cm.) above the patella. Fluctuation can be readily detected when one hand is placed above the patella, and the fingers of the other hand compress the tissues on either side of the ligamentum patellæ. When the effusion is considerable the patella is felt to float, and on pressing it sharply backwards can be made to tape against the intercondyloid notch of the femur (*patellar tap*) A smaller effusion is recognized

by pressing the fluid downwards from the suprapatellar pouch with the knee fully extended, when the fluid will be seen to fill up the normal hollow on the inner side of the knee joint. Enlargement of the prepatellar bursa is recognized by the swelling being central and in front of the patella, so that its outline is obscured

Ankle The foot is held in a position of slight equinus, and the hollows between the tendo Achillis and the malleoli are replaced by fluctuant swellings, while the dorsal tendons are displaced forwards, and a fluid swelling appears in front of each malleolus. Enlargement of the bursa beneath the tendo Achillis is so obviously confined to the back of the joint that it should never be mistaken for true synovitis of the ankle.

Position of Rest. The position to be adopted in the treatment of inflamed joints is a most important matter and must be carefully noted It may be termed for convenience the "position of rest" and is such as not only gives comfort to the patient, but also ensures that if the joint should become fixed, the maximum of utility is secured for the limb Each joint must be separately studied

Shoulder The arm may simply be bandaged to the side if there is little likelihood of subsequent stiffness but whenever ankylosis is possible, it should be fixed at an angle of about 40 degrees away from the side and 15 degrees forward from the coronal plane This permits later of a much greater range of usefulness, inasmuch as it utilizes the scapular movements. Fixation with greater abduction than this prevents the arm being placed to the side, as there is only a limited range of scapular movement.

Elbow This of course includes the superior radio-ulnar joint. The joint is placed on a splint and flexed to a little less than a right angle, so that the hand can be approximated to the mouth. The palm of the hand must be turned slightly upwards, *i e* so that the patient can just see into it. Before allowing the joint to become fixed in this position, however it is well to ascertain from the patient what his work is, and what position of the arm will be most useful to him If both elbows are threatened with stiffness, one should be kept in a position of flexion to a little more than a right angle, the other to a little less. In a person whose occupation is clerical, it may be best to allow fixity of the left forearm to occur in a position of pronation so as to enable him to hold papers down to the table when writing.

Wrist This must always be immobilized in a position of slight dorsiflexion, so as to improve the power of grasping. The fixation should not include the fingers and movements must be maintained by active exercises. Adhesions form rapidly in the small joints of the fingers and in tendon sheaths, when prolonged fixation of the fingers is associated with septic changes in the wrist or arm

Hip This joint is best immobilized in a position of moderate flexion (25 degrees) and slight abduction, so as to counteract the pull of the powerful adductors, which are always liable to adduct the limb. A careful watch must be kept on the patient's pelvis, to make sure that it has not been tilted by muscular action, so as to bring about once again a position of adduction this warning is especially necessary in children An abduction frame which controls both legs may be used or in lieu of this, a Thomas's splint on each side. In the latter case the necessary abduction is maintained by slinging the splints in the desired position.

Knee The most convenient position for permanent fixation is one of

slight flexion, as this assists in mounting stairs and in sitting. About 10 to 15 degrees is sufficient

Ankle The foot should be at right angles to the leg.

Operations on Joints. Joints are known to possess a considerable power of resistance to infection by pyogenic organisms, yet any breach of strict aseptic precautions is only too likely to be followed by disastrous results endangering both the utility of the limb and also the life of the patient hence *the most minute care must be taken in all operations which involve the opening of joints* Very thorough sterilization of the skin must be insisted on, and fingers should never be introduced into the wound A fresh knife should be employed to open the synovial membrane No antiseptics are allowed to enter the joint as they are irritating, and may cause a synovial effusion which becomes a suitable medium for the growth of bacteria, if such happen to be present.

At the conclusion of the intra-articular manipulation the joint should, if necessary be gently irrigated with hot saline solution so as to remove blood clots, and carefully closed in layers. Drainage is most undesirable. The limb is usually kept at rest for a few days perhaps on a splint, and then movements are cautiously permitted. Active contractions of the surrounding muscles must be employed from the first day Weight bearing is not allowed until the patient has regained muscle control of the limb and until all pains and muscle spasm has gone.

Infective Arthritis

As in the case of infection of bone, joints may become infected by direct wounds or *via* the blood-stream

Penetrating Wounds of Joints These may occur as a result of stabs, gunshot wounds, or from falls on to nails, glass and other sharp objects. Open dislocations of joints are rare, but occur occasionally in the fingers. The infection is likely to be mixed and to include staphylococci, streptococci and the coliform group while in war wounds, anaerobic infection is likely Post-operative infection of joints is now rarely encountered, and when it occurs is likely to be the result of an infected hæmatoma. Sometimes after a meniscectomy the knee becomes tense with blood, and the patient runs a temperature of 100 to 101 degrees, together with some enlargement of the inguinal lymph nodes. The surgeon goes through an anxious time and will be well advised to aspirate the joint at once. Culture often fails to grow an organism and the symptoms settle down in a few days. If they persist or if organisms are grown, however the joint is in danger of destruction and the life of the patient may be threatened.

Spread from Local Osteomyelitis Certain joints, notably the hip, elbow and shoulder are likely to become infected as a result of osteomyelitis of the neighbouring bones.

Blood-stream Infection A joint may become infected from the blood stream, in the same way that acute hæmatogenous osteomyelitis is initiated. The likely organisms are the staphylococcus, pneumococcus, gonococcus and streptococcus Staphylococcal arthritis is usually secondary to bone infection but may occur as a primary arthritis. In infants pneumococcal infection may be secondary to pneumonia and was common before the advent of antibiotics, but is now rarely seen In the past the gonococcus was often responsible for the combination of ophthalmia neonatorum and

joint infections This is now very rare. Gonorrhœal arthritis is occasionally seen during the acute stage of gonorrhœa in adults. The arthritis, which is sometimes suppurative, may lead to ankylosis of the joint.

Streptococcal joint infection is encountered after streptococcal pharyngitis or tonsillitis and was seen in connection with scarlet fever in the days when this was a severe disease.

Acute Non-suppurative Arthritis. In this affection the inflammation is limited almost entirely to the synovial membrane, the ligaments and other structures of the joint being but little affected. It is sometimes attributed to cold or injury the organisms reaching the joint from the blood as is also the case in the milder pyæmic and gonococcal affections.

Pathology Acute synovitis is characterized by hyperæmia of the synovial membrane, and exudation of plasma and leucocytes firstly into the substance of the membrane, causing it to be thickened and spongy and subsequently into the joint the endothelium also proliferates, and is shed. In the early stages the effusion consists of synovia, diluted with blood-plasma and often discoloured with blood in traumatic cases. After a time the plasma may coagulate, depositing lymph upon the articular surfaces. This lymph may either be removed by a natural process of absorption when the inflammation comes to an end, or it may become organized, so as to form adhesions, which consist of loose fibrocicatricial tissue containing a few delicate blood-vessels and covered with endothelium from adjacent serous surfaces. In some varieties, especially if repair is not quickly established a certain amount of perisynovial inflammation follows, resulting in congestion, infiltration and perhaps relaxation of the ligaments.

The clinical signs of acute synovitis consist in the joint becoming painful and distended and in the case of superficial joints, hot to the touch and even red. The limb is maintained by muscular spasm in that position which gives the most ease, *viz* that in which its capacity is the greatest. This is usually one of slight flexion.

Treatment The limb should be immobilized with the joint in slight flexion. In the lower limb light skin traction is desirable. The effusion should be aspirated to relieve tension in the joint and to provide material for bacteriological investigation. The fluid obtained will appear thin and turbid and contain pus cells but will not present the appearance of pus to the naked eye. When the joint has been emptied of fluid and before the needle is removed, some antibiotic solution may be injected into it. Crystalline penicillin should be used in a dosage of 300,000 units diluted in a few millilitres of saline. This may be repeated at regular intervals. Antibiotics should also be given by intramuscular injection When the acute symptoms have subsided, the muscle tone must be restored and active movement allowed within the limits of pain. Weight bearing is not permitted until the joint feels cool, swelling has subsided, and until good muscle power is present. It is wise to support the joint with an elastic bandage

Limitation of movement by adhesions may result, and the full range may be restored by the activity of the patient. Manipulation if used at all, should be done only at a late stage and then very cautiously because the forcible tearing of adhesions may reactivate further infection.

Acute Suppurative Arthritis. Suppuration may follow infection of a joint. The degree of damage which results will depend upon the virulence of the

infecting organisms, the resistance of the patient and the efficacy of the treatment employed

Pathology The inflammation may start in the synovial membrane or beneath the articular cartilage The whole joint is soon involved The synovial membrane becomes thickened and hyperæmic and the ligaments and capsule are also involved Indeed there is often considerable inflam matory reaction in the periarticular tissues.

The articular cartilage may be destroyed partially or completely and when inspected is seen to be pitted. These " pits " occur at places where the articular cartilage has been perforated possibly by the action of ferments in the exudate. They are lined by granulation tissue which also grows into the more peripheral portions of the cartilage from the synovial membrane. The cartilage becomes stripped from the underlying bone which itself be comes inflamed Periosteal reaction is responsible for the stalactite type of osteophytes laid down in the neighbourhood of the joint (Fig. 17 10) Dis-

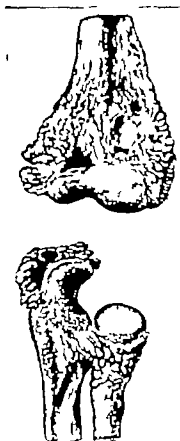


FIG. 17 10. ACUTE SUPPURATIVE ARTHRITIS OF THE ELBOW SHOWING THE CARIOUS SURFACES DEVOID OF CARTILAGE, AND THE DEVELOPMENT OF THE STALACTITE TYPE OF OSTEOPHYTES.

tension of the joint stretches the ligaments softened by hyperæmia and pathological dislocation may result, with much subsequent deformity The outcome of a suppurative arthritis may in favourable circumstances be that of resolution, with full restoration of movement. More often, however some degree of ankylosis will result. When destruction of the articular

cartilage has been incomplete, the ankylosis will be fibrous, but when complete, ankylosis by bone is likely

Clinical Signs The early signs are those of an infective arthritis which may progress to suppuration The joint is swollen and distended with fluid it is hot to the touch and tender movements are often extremely painful, sleep becomes difficult, because relaxation of muscles allows movement and pain which wakes the patient. Pyrexia of moderate degree will be present and there will be enlargement of the lymph nodes draining the joint. A blood count will show a polymorphonuclear leucocytosis. The joint should be aspirated both as a diagnostic and therapeutic procedure.

Radiography may reveal no change, but distension of the joint cavity will sometimes be indicated by a widening of the joint space.

Treatment The essential points in treatment are (*a*) Rest on a splint, with or without extension (*b*) removal of the pus by aspiration at intervals (*c*) the use of antibiotics both locally in the joint and by intramuscular injection and (*d*) the improvement of the natural resistance of the patient by all available means, including blood transfusion

Aspiration may be carried out under local or general anæsthesia. It is important to use a wide bore needle. Satisfactory irrigation of the joint cavity is not possible through a needle. Viscid pus, or unsatisfactory response to aspiration may render an arthrotomy advisable The joint cavity is opened through a small incision and irrigated with normal saline solution through a small catheter Some antibiotic solution is left in the joint which is then closed by stitching skin or muscle but leaving the capsule open.

On no account should a drainage tube be left in the joint as this will favour ankylosis A sufficient bulk of fluid must be used to carry the antibiotic to all parts, 100,000 to 500 000 units of penicillin being dissolved in 5 to 10 ml. of water

Occasionally the response to treatment will be unfavourable and it may be necessary to sacrifice the joint by wide incisions in order to save life. In this case ankylosis by fibrous tissue or bone must be accepted.

After treatment Active movement may be started when the wounds have healed or when the signs of inflammation have subsided. Increased heat or muscle spasm are indications for continued immobilization. Increase of range of movement may be achieved gradually and weight bearing should not be allowed until the patient is pain free and has good muscle control of the joint.

Acute Arthritis of Special Joints

The Shoulder *Infection sometimes occurs* through the axilla, where the capsule is weak and easily invaded by organisms, as after an axillary cellulitis more frequently it follows a penetrating injury Severe pain is caused by any movement of the arm affecting the joint, and if abscesses form, they will come to the surface in front of or behind the deltoid, or in the axilla. It may suffice to open the joint anteriorly and irrigate it but, if necessary a counter-opening should be made behind by cutting down on a pair of artery forceps pushed backwards through the capsule. In many instances the patient s condition will not improve until the head of the bone has been excised and then the subsequent results as regards movement and power of the arm are, on the whole satisfactory

The Elbow In the elbow joint there are no points requiring special

mention as to clinical history or results although it must be remembered that the superior radio-ulnar articulation is necessarily involved and hence the power of pronation and supination of the hand is threatened As to treatment incisions should be made on either side of the olecranon the ulnar nerve being avoided The limb is then placed on a rectangular splint e g Robert Jones s flexed arm splint which permits of extension the hand is placed midway between pronation and supination In an adult excision may be undertaken as soon as the acute stage has passed in order to obtain a movable elbow but in children where the growth is incomplete, it is better to allow ankylosis to occur and excise if need be, at a later date.



FIG. 17 11 CHRONIC OSTEOMYELITIS OF THE LEFT FEMORAL SHAFT TOGETHER WITH PATHOLOGICAL DISLOCATION OF THE HIP JOINT

The Wrist. This may be infected secondarily to septic conditions following operations on ganglia in the neighbourhood or through direct injury the various carpal joints soon becoming infected owing to their anatomical arrangement. The essential treatment consists in free incisions parallel with the tendons, and avoiding the sheaths Ankylosis usually results.

The Hip. Acute arthritis of the hip joint is usually a sequal of acute infective osteomyelitis attacking the upper end of the shaft of the femur and involving the joint, owing to the epiphyseal cartilage being intracapsular it also results from pyæmia, and from penetrating injuries, which in civilian life are rare. The symptoms are similar to those of the first stage of tuber culous disease but much more acute. There is high fever together with intense pain, marked flexion and eversion of the limb early suppuration, and rapid disorganization if not properly treated indeed where nothing is

done, and the patient lives long enough, the head of the bone may be entirely absorbed or detached and *remains as a sequestrum* in the disorganized articular cavity As soon as the capsule gives way the pus may come to the surface in any of the usual localities for hip-joint abscesses, and the limb then becomes inverted and adducted spontaneous dislocation follows, and the head of the bone or what remains of it, travels upwards and backwards on the dorsum ilii In treating these cases, the *joint should be freely* laid open in the situation which appears most favourable. The anterior incision is more suitable for the early and the posterior for the later stages, when the head of the bone is either dislocated, or remains *in situ* and separated from the shaft A double opening may sometimes be used with advantage.

The Knee. This is more frequently involved than any other joint and is usually infected from without. The symptoms are exceedingly typical the pain is very acute, and the joint hot and distended to its utmost capacity *the limb lying semiflexed and on its outer side. Left to itself* the capsule gives way and suppuration rapidly extends upwards beneath the vasti, giving rise to large abscesses, which ultimately find their way to the surface. The deformity gradually increases, until in the worst forms the tibia slips behind the condyles of the femur the leg is flexed to a right angle and rotated outwards, and if the limb has long rested on its outer side, considerable lateral displacement may also occur Early and efficient treatment will prevent such a disaster If this fail, the joint should be freely incised on each side of the patella, so as to open up the suprapatellar pouch, and the whole articular cavity well washed out In severe cases counter-openings must be made behind so as to drain the posterior pockets of the synovial cavity A sinus forceps is introduced from the front, and passed backwards on either side so as to project posteriorly and the point then cut down on The *nerves and tendons of the popliteal space must of course be carefully guarded.* In these severe cases it may be wiser however to lay the joint freely open from the front by a wide U-shaped incision, dividing the ligamentum patellæ and turning up that bone By flexing the leg completely the femoral condyles can be exposed sufficiently to enable their posterior rounded ends to be removed by a vertical saw-cut. Plenty of room is thereby secured for the insertion of drainage-tubes from either side or for irrigation purposes. The anterior flap can be replaced and sutured in position

The Ankle. When this joint is involved, *amputation* has often to be resorted to in consequence of the difficulty of securing good drainage, although excision of the talus will sometimes lead to a good result.

Ankylosis and Adhesions

The final result of trauma or disease of a joint may be that of resolution with return of normal function, or ankylosis. By ankylosis is meant a condition of immobility partial or complete.

False Ankylosis. This term *is applied to a condition* resulting from extra-articular lesions. It may be either fibrous or osseous, and is due to cicatricial contraction of the skin, shortening or fibrosis of muscles, or to the development of bony tissue within them (*myositis ossificans*). *A common* and troublesome form of false ankylosis after fractures or gunshot wounds is due to the fixation of muscles to the underlying bone. Thus, in many cases the quadriceps is fixed to the front of the femur by such dense *fibrous* adhesions that movement of the knee is impossible, although the patella

may be freely mobile from side to side Similarly the triceps may be fixed to the back of the humerus and prevent movement of the elbow

Adhesions. The inflammatory exudate may not be absorbed completely Fibrin may be deposited within the joint or in the substance of the capsule This becomes organized into fibrous tissue which may be present as strands within the joint, or glue the synovial membrane to the capsule Sometimes the ligaments or capsule are thickened by intercellular fibrosis and thus lose elasticity as may happen in the shoulder joint. Great loss of movement may result.

In other joints the loss may be slight, and often this loss is in a single movement only the range of other movements being full

Manipulation of Joints If the movements of a joint are limited by the presence of adhesions, the range of movement must be restored by active exercise Only when no increase of range can be recorded week by week may resort be had to manipulation The selection of cases requiring manipulation must be carefully made and the following points should be considered (*a*) Limitation of movement due to a general arthritis, however mild, is characterized by pain in every direction with adhesions suitable for breaking down there is a certain degree of painless movement, and pain only starts when this is exceeded, and the adhesions are stretched. (*b*) Massive adhesions such as those which form after serious inflammation hold out little prospect of improvement by force as the divided surfaces have to heal, and in so doing fresh adhesions form. (*c*) The time for breaking down adhesions is late so that the adhesions may be avascular Otherwise further hæmorrhage and more adhesion formation will result. (*d*) The actual breaking down of the adhesions should be accomplished by steady force, and not by intermittent jerks. In the less severe cases, a full range of movements should be aimed at from the first, and the freedom of all movements of the joint should be tested In the more severe cases it may be desirable not to do too much at a time as a good deal of reaction often follows the manipulation may be repeated more than once (*e*) When it is likely that a good deal of force will be employed, it is wise as a precautionary measure to place splints on the limb above and below the joints, since it is not difficult to break one of the bones. (*f*) The joint is kept at rest for a day or two after the manipulation, but once at least each day the limb should be put through a full range of the movements secured. (*g*) As already pointed out, no attempt should be undertaken to break down adhesions in a joint in the neighbourhood of septic sinuses intra-articular hæmorrhage followed by suppuration is only too likely to follow

True Ankylosis. This always involves the articular structures, and is either fibrous or bony

Fibrous or Incomplete Ankylosis This results (*a*) from thickening and contraction of the ligaments, the result of infective arthritis (*b*) from the formation of cord or band-like adhesions within the joint, after acute synovitis or fractures involving the articular surface (*c*) from erosion of the cartilage and exposure of the bone, as in acute or tuberculous arthritis granulations sprout up on each side and by their union lead to dense fibrous adhesions between the articular surfaces Some amount of movement is possible in most of these cases.

Complete or Osseous Ankylosis Synostosis arises from the union of either the whole or part of the opposing surfaces left by the destruction

of the cartilage, the bond of union, at first fibrocicatricial, being subsequently ossified (Fig 17 12) it may be simulated by the interlocking of osteophytes formed at the margin of the bone in osteo-arthritis or Charcot's disease.

The position in which ankylosis occurs and the effects thus produced differ according to the joint affected



FIG. 17 12. BONY ANKYLOSIS OF THE HIP-JOINT POSTERIOR VIEW
(*King's College Hospital Museum*)

In the *shoulder* the existence of immobility is of less importance than elsewhere owing to the free movements of the scapula and clavicle. The deltoid muscle is generally much atrophied. The *elbow joint* is very commonly ankylosed on account of its exposed position and the frequency of fracture-dislocations in its neighbourhood The formation of callus filling up the olecranon and coronoid fossæ and the adhesions likely to form within the joint in these cases, readily explain its frequency The most favourable position for ankylosis is when the arm is flexed to a little more than a right angle, with the hand slightly supinated so that the patient can see into the palm. By this means access to the mouth is possible and the hand can be used for feeding purposes. The work of the patient must, however be considered. The *wrist* is most commonly fixed as a result of rheumatic arthritis.

In the *hip-joint* much depends upon the treatment as to whether the

ankylosis takes place in a good or bad position Slight flexion of the thigh (about 25 degrees) is probably the best position to ensure comfort both in sitting and standing, combined with moderate abduction In neglected cases the thigh may be in a position of adduction and internal rotation crossing in front of the other leg (Fig 17 3) Occasionally a scissor like



FIG 17 13 ANKYLOSIS OF THE RIGHT HIP-JOINT FOLLOWING SUPPURATIVE ARTHRITIS.
Note adduction, internal rotation and shortening of the leg.

deformity has resulted from inflammation of both hip-joints, one leg lying in front of the other progression is accomplished with difficulty the body twisting at each step and crutches are often needed In ankylosis of the *knee-joint* an absolutely straight position is not so serviceable as when some slight degree of flexion (15 degrees) is present. Unless care is taken in treating the causative affection, ankylosis is only too likely to be associated with deformity The knee becomes much bent, and the tibia is displaced backwards on the femur while external rotation and even lateral displacement of the tibia are likely to supervene if the patient is allowed to lie with his leg on its outer aspect. In the *ankle-joint* considerable trouble may arise from immobility unless the foot is at right angles to the leg.

When a joint is the site of fibrous ankylosis there will usually be a slight degree of movement. This may be difficult to detect, particularly in the hip joint. When the fibrous tissue consists of short strands, pain will be caused by passive movement. Therefore when pain is elicited the ankylosis is fibrous ankylosis by bone is painless. If the ankylosis is by long strands of fibrous tissue, there will be obvious mobility and little or no pain This may happen in some fractures and is the aim of certain operations in which bone is removed in order to obtain movement. It is thus important to recognize two types of fibrous ankylosis, " long " and " short."

Radiology will not give a certain diagnosis of ankylosis by bone unless bone trabeculæ can be seen passing across the joint.

Treatment of Ankylosis. This will vary considerably according to its cause In the simple forms of fibrous ankylosis, due to the presence of adhesions of no density much may be done by manipulation and exercises. Some adhesions may be dealt with by forcible movements under an anæsthetic, the surgeon ever keeping in mind that the bones involved may be atrophic and easily broken. Others are better treated more gradually efforts being directed to lengthen and stretch the adhesions rather than to break them Remedial exercises may be useful.

An exception to all vigorous treatment of this type, as also to some of the operative methods suggested below is made in the case of ankylosis following sepsis or tuberculous disease. The surgeon can never be certain that infective foci are not encapsulated in the fibrous tissue and active treatment might once again light up the disease

It is useless to attempt the rupture or division by open operation of dense adhesions, as they are certain to form again. These cases are best treated by arthrodesis. If the ankylosis has been caused by trauma and when movement is essential, some form of arthroplasty may be employed A simple excision of the joint may give better function than an operation in which a metal prosthesis is used

Excision of Joints This is still occasionally required, especially in the *elbow* but takes on the form of an arthroplasty in the majority of cases. It should never be considered when a man has a strong useful arm, even if stiff

At the *hip-joint* ankylosis in a bad position is most commonly due to tuberculous disease, and, as already stated arthroplasty is then not desirable. Most frequently the thigh is flexed on the pelvis and possibly adducted, the result being a most ungainly method of progression. Subtrochanteric osteotomy of the femur is the operation of choice a small incision is made just below the trochanter and through this an osteotome is introduced and the bone divided This may well be combined with an ischiofemoral arthrodesis (see p 468) To put the limb in a good position, tenotomy of the adductors is usually required and this is easily effected subcutaneously close to the pubes. The after-treatment must be sufficiently long to ensure sound and solid union of the bone, as the adductors are powerful and can readily lead to displacement when the callus is soft. In non-tuberculous ankylosis of the hip one of the forms of arthroplasty may be used.

In the *knee* bony ankylosis with deformity will frequently require the removal of a wedge-shaped fragment (cuneiform osteotomy) in order to overcome the deformity where, however the ankylosis is fibrous, it is better to convert this into a bony ankylosis rather than attempt arthroplasty the success of which may be uncertain.

Special Forms of Synovitis and Arthritis

Typhoid Disease of Joints. This occurs either as a synovitis or arthritis, and is due to a blood infection with the *Salmonella typhosa*, either alone or in conjunction with pyogenic organisms. If purely typhoid in type, suppuration does not occur there may be a mild synovitis in several joints, or a marked effusion in one followed by relaxation of ligaments, so that spontaneous dislocation may occur this is most marked in the hip-joint. The prognosis

is favourable in these purely typhoid lesions if deformity is prevented effusion in excess is treated by aspiration, and washing out a recurrence may require drainage. If pyococci are present either alone or together with the typhoid bacilli suppuration develops and masks the typhoid element Treatment includes chloramphenicol in full dosage

Pneumococcal Arthritis. In the course of an acute pneumonia, the pneumococcus is occasionally disseminated throughout the body and is then very likely to attack a joint which has been already damaged giving rise to a suppurative arthritis with an effusion of thick creamy pus, or sometimes to a milder form of synovitis Males are more often affected than females, and the upper rather than the lower extremity Occasionally more than one joint is involved, and, with the exception of the hip the larger joints are attacked rather than the smaller There are no special peculiarities in this disease which may be controlled by antibiotics. If suppuration has occurred the joint must be aspirated or opened and irrigated

Occasionally pneumococcal arthritis may occur as a primary infection The symptoms are those of a subacute arthritis with effusion.

Gonococcal Arthritis. This is caused by a blood-borne infection with the gonococcus from the primary focus. The joint is also sometimes infected with pyogenic organisms and then the prognosis is worse. In the later stages the fluid from the joint is found to be sterile. Such an occurrence is suggestive of a gonococcal arthritis as other forms of suppurative arthritis seldom produce sterile pus. While usually seen in men suffering from gonococcal urethritis, it has been known to follow ophthalmia neonatorum. It may be provoked by passing bougies on a patient with gleet. It generally commences about the third week of the gonorrhoeal attack when the discharge is becoming subacute but may also appear at a much later date It may affect one or many joints, the knee ankle and wrist being those most frequently attacked. The lesions may be symmetrical on the two sides of the body

Tuberculous Disease of Bones and Joints

This is always a blood stream infection from a primary focus, usually in the lymph nodes or lungs. It is often impossible to determine the origin of the infection with certainty but a search should be made particularly of the cervical, bronchial and mesenteric lymph nodes, and the chest and genito-urinary tract should be examined

The patient who presents with a tuberculous bone or joint may have no knowledge of previous infection, but a careful case history will often reveal that he has been in contact with a relative who has open pulmonary tuberculosis. The onset of skeletal tuberculosis is insidious, and it is difficult to decide whether injury previous ill health or other factors play any part in the selection of the site of disease. Many patients appear to be healthy and well nourished and show no obvious signs of systemic disease.

Tuberculous Disease of Bone. The site of the primary bone infection is usually in the epiphysis or metaphysis. Very rarely is the diaphysis affected. Tuberculous granulation tissue is produced, which invades and destroys the cancellous and cortical bone, causing rarefaction or caries (Fig. 17 14). In some situations the bone structure is absorbed with little or no pus formation (*caries sicca*) in others, an abscess will be formed (*caries suppurativa*) (Fig. 17 15).

In the process of healing the surrounding bone reacts by condensation

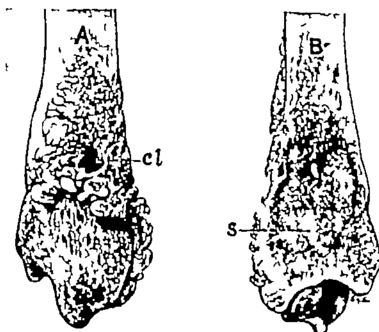


FIG 17 14 LOWER END OF THE TIBIA AFFECTED WITH TUBERCULOUS DISEASE (*King's College Hospital Museum.*)

In A a subperiosteal deposit of new bone is seen surrounding an opening (cl) which leads into the interior of the bone In B the interior of the same bone is seen, and shows a sequestrum (S) just above the epiphyseal line. The ankle-joint is healthy



FIG. 17 15 TUBERCULOUS CARIES IN THE METAPHYSIS OF THE TIBIA WITH DESTRUCTION OF THE EPIPHYSIS.

and a skiagram will show a cavity surrounded by sclerotic bone an appearance similar to that of a chronic staphylococcal or Brodie's abscess Endarteritis of blood vessels leads to necrosis of small areas of bone which form sequestra. These are soft pliable and porous, in contrast to the solid dense sequestra of staphylococcal infection

In most areas there will be no periosteal reaction again in contrast to staphylococcal osteomyelitis, but an exception to this is to be found in the bones of the fingers and toes, where massive periosteal new bone may cause much thickening of the shaft (*tuberculous dactylitis*)



FIG. 17 16. TUBERCULOUS DACTYLITIS. The disease started in the proximal phalanx and has spread to the periosteum.



FIG 17 17 TUBERCULOUS DACTYLITIS OF THE FOURTH METACARPAL. The new bone formation is well shown.

Tuberculous Osteitis. This may occur in (*a*) long bones and (*b*) bones of the hand and foot.

In the case of long bones the condition is only occasionally non articular affecting the cancellous tissue in the epiphysis or metaphysis. There will be pain in the affected bone, with tenderness and increased skin temperature. The neighbouring joint may contain an effusion and the muscles will be wasted When the site is in the lower limb, a limp will be present. Radiology may reveal an area of rarefaction in the bone, without any periosteal reaction. Differential diagnosis must include subacute staphylococcal osteomyelitis, bone tumours and osteitis fibrosa cystica.

The Hand When the digits of the hand are affected the condition is known as tuberculous dactylitis. The affected segment of the finger becomes slowly enlarged bulbous and painful, the pain being, however slight in amount though sometimes worse at night. At first the finger looks white and the skin is smooth and shiny (Fig. 17 16) but after a time one spot rapidly increases in size, becoming red and tender and finally an abscess forms which bursts or is opened leaving a sinus, down which a probe can be passed into the carious interior of the bone. Occasionally contiguous joints are involved in this process, while the tendon sheaths are also liable to be affected a large portion of the swelling is due to periosteal infiltration (Fig. 17 17) In some cases the bone appears to be expanded but the term expansion is scarcely correct, inasmuch as the enlargement is due to absorption on the inner aspect, whilst there is formation of new bone under the periosteum.

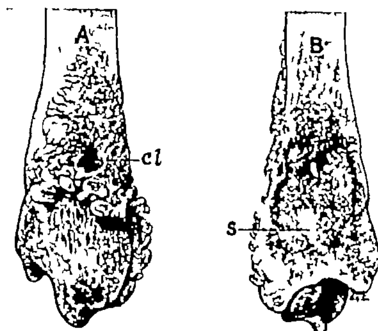


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Natural cure without suppuration occurs when the child is placed under suitable hygienic conditions, but even then the growth of the phalanx may be hindered, and the finger remains shortened.

The Foot Any of the bones of the tarsus may be affected, the talus and calcaneum being the most common. The disease will usually spread to the joints, or to other bones. In the case of the phalanges the lesion may remain purely osseous, as in the hand The affected part of the foot becomes swollen and shiny and it may be difficult to determine whether the primary focus is in bone or joint.

When the disease starts in the talus it is likely to spread to the ankle joint. If in the navicular the three cuneiform bones may be affected. In this situation, a warm tender swelling in a child of three or four years may be caused by Köhler's disease, one of the forms of osteochondritis (p. 485). In general, tuberculosis of the tarsus is likely to be confused, in its early stages, with subacute infection or rheumatoid arthritis. The presence of other joint swellings may provide a clue to the diagnosis.

Treatment is both general and local. The foot must be immobilized until there is clinical and radiological evidence of healing. The ideal operation would be complete excision of the diseased tissue, but this is rarely possible. Abscesses should be aspirated, and any sinuses treated by curettage in order to remove as much of the carious bone as possible. In patients past middle age, the question of amputation ought seriously to be considered.

Tuberculous Disease of the Ribs and Sternum. The ribs are more frequently affected than the sternum The disease may arise primarily in the bone, but more often it is secondary to a tuberculous abscess arising in mediastinal lymph nodes, or coming from the pleura or spine. Several ribs may be involved. Caries of bone with caseation is usual and the abscess points either about the middle of the rib or near the costochondral junction. The cavity may be hour glass in shape, a narrow neck connecting the subcutaneous and deep abscesses.

Unless the disease is a primary tuberculous osteomyelitis, excision of the rib is of little help The sinus can be traced backwards between the pleura and intercostal muscles, to the posterior mediastinum, but removal of the caseating lymph nodes is not possible Healing will be achieved by conservative treatment extending over a long period.

Tuberculosis of Joints

Pathology The disease may start in (*a*) the synovial membrane or (*b*) the adjacent bone In the latter case it may be subchondral, epiphyseal or metaphyseal.

Synovial Infection. The synovial membrane becomes thickened and œdematous, and in the early stage will be found studded with the small grey nodules called tubercles. These may later amalgamate into larger areas which caseate and burst into the joint cavity The process of local caseation is due to endarteritis and obliteration of small blood vessels, but the joint as a whole reacts to the infection by hyperæmia and will on examination feel warm. Synovial effusion is small and it is unusual to see the large collection of fluid known as "tuberculous hydrops." As the disease progresses, the synovial membrane is converted into granulation tissue which can be seen growing over and destroying the articular cartilage as ivy creeps along

a wall. Erosion of the cartilage allows the granulations to penetrate through the underlying bone which itself becomes carious Granulation tissue can now grow between bone and articular cartilage which is separated and flakes off in sheets Caseous material collects in the joint together with cartilaginous débris, forming a tuberculous abscess, which in time may burst through the capsule. The abscess may ulcerate through the skin forming a sinus, or may track along muscle planes for some distance

When the joint changes are advanced, there will also be some involvement of the periarticular tissues, the capsule, subcutaneous fat, muscles and tendons. These structures become infiltrated with inflammatory products and become swollen and gelatinous. These changes together with the swelling of the synovial membrane constitute the "white swelling of the knee or elbow a descriptive term found in the older text books

Bone Infection. In adults the focus is often in subchondral bone but in children it is more frequently epiphyseal The joint is infected by extension of the disease through the articular cartilage or by extension laterally through the cortical bone of the epiphysis An example of the latter mode of spread may be seen in the hip, where the epiphysis and metaphysis are contained inside the capsule of the joint. The first indication that the joint has become infected may be a synovial effusion, followed by slow extension of the disease throughout the joint Sometimes however a tuberculous abscess of bone bursts into the joint with symptoms of an acute arthritis. If rested the joint will usually settle down to the more chronic type of disease.

Prognosis. Before the use of streptomycin, resolution of tuberculous infection of a joint was exceptional, if indeed it ever took place. The disease might become quiescent after long treatment, but was liable to become active again as a result of poor health or trauma. Furthermore, reinfection of the blood stream might occur with the risk of miliary tuberculosis or tuberculous meningitis. The prognosis was best in the synovial type of disease which did not spread to and destroy articular cartilage. Healing was by fibrosis and the formation of adhesions with limited joint movement was expected. With destruction of articular cartilage the joint became disorganized and fibrous ankylosis resulted often with gross deformity of the limb Persistent sinuses were liable to secondary infection with pyogenic organisms and the mixed infection might in some cases lead to bony ankylosis. A serious and often fatal result of mixed infection was lardaceous or amyloid disease in the liver spleen and kidneys. All this is still true, but the outlook has been entirely changed in Britain during the last few years by a number of factors

(1) Improvement of the general standard of living, which includes diet, hygiene and housing. Improvement in medical services especially preventive, *e g* school medical services.

(2) The pasteurization of milk, which is now almost universal. Whereas formerly infection from milk was common, now the majority of infections come from human sources.

(3) The advent of streptomycin, para-aminosalicylic acid (PAS) and iso-nicotinic acid hydrazide (INH) The use of these drugs in combination, has not only made possible the healing of early tuberculous lesions, but has provided an antibiotic and chemical cover so that operations can be carried out with a greatly diminished risk of miliary spread.

Clinical Signs. The onset of the disease is nearly always insidious and

in some cases it appears to be related to trauma. In addition to the clinical examination of the joint, special attention must be given to the general condition of the patient, with special reference to appearance, loss of weight and the evidence of previous tuberculous lesions.

The early local signs and symptoms are

Pain Often this is slight but it may be aggravated by movement or vibration

Swelling This can be appreciated most readily in superficial joints like the knee and elbow The swelling is diffuse, consisting of thickened synovial membrane with perhaps a trace of effusion but fluctuation will be absent. In the later stages of the disease the periarticular tissues become involved, or an abscess may be present.

Limitation of Movement It is typical of an inflamed joint that movement is limited in all directions. The limitation is caused by muscle spasm which "guards the joint. "Night starts" of pain sometimes occur when the spasm is relaxed during sleep

Position The joint assumes the position of maximum comfort. This is always that of flexion, but in the hip the limb will be abducted and laterally rotated

Increased Heat The skin temperature will be raised and this can easily be appreciated by the hand This sign is not so apparent as with pyogenic joint infections.

Lymph Nodes The nodes draining the joint should be palpated and may be found enlarged Biopsy of one of these may form a useful diagnostic aid

Radiological Examination Skiagrams of the corresponding joints of both limbs are essential. The antero-posterior views should, if possible, be



FIG. 17 18 EARLY TUBERCULOSIS OF THE HIP JOINT SHOWING THE NARROW JOINT SPACE AND EROSION OF THE NECK OF THE FEMUR
The disease probably started in the femoral neck.

taken on one film with one exposure so that the bone densities of the two sides are comparable In addition a skiagram of the chest should be taken

The earliest radiological sign of joint hyperæmia is that of generalized osteoporosis of the bone in the vicinity This is not diagnostic of tuberculosis and may be present in a septic or traumatic arthritis, or after immobilization At a later stage of the disease a local area of bone destruction may be seen (Fig. 17 18) Synovial tuberculosis may be present for many weeks before any bone changes are shown on the skiagram

Laboratory Aids to Diagnosis. A differential blood count may show a preponderance of lymphocytes as may also fluid aspirated from the joint.

In young children a Mantoux Test should be done When negative to 1 in 100 dilution, the diagnosis of tuberculosis can be almost excluded, but not quite, for if the disease is rapidly advancing and the child very ill, the Mantoux may not convert to a positive test for some months.

The finding of tuberculous tissue in a lymph node removed from the drainage area of the joint, is strong circumstantial evidence of tuberculous arthritis. Biopsy of the synovial membrane is always advisable in doubtful cases The material removed should be divided into halves, one half being emulsified and injected into a guinea pig, the other being subjected to histological examination. The only positive proof of a tuberculous infection is that the tubercle bacilli be cultured from the tissues, and this should be attempted whenever conditions allow

In most cases the diagnosis is made on the accumulated circumstantial evidence of clinical, radiological and pathological findings, supported by the passage of time and the outcome of the disease. The differential diagnosis must include trauma, infective arthritis, rheumatoid arthritis and in the hip oint, pseudocoxalgia. In countries where syphilis is rife, syphilitic epiphysitis must also be considered

Treatment The treatment of bone and joint tuberculosis is conducted along lines similar to that for other forms of the disease. Certain general principles must be observed and these have not been altered by the advent of antibiotics and chemotherapy although the duration of treatment has been considerably shortened It is important to remember that not only has the patient a tuberculous joint, but also that he is a tuberculous patient, liable at any time to show evidence of the disease elsewhere in his body The lungs and genito-urinary tract are likely sites for further spread.

Treatment may be classified under (*a*) General, (*b*) Antibiotic and chemotherapeutic and (*c*) Local.

General Treatment This is necessary for any tuberculous patient, who should be transferred from an acute hospital to a long-stay hospital as soon as convenient. There are several reasons for this. The long-stay hospital should be situated in the country or by the sea where more clean air and sun light may be expected than in a city and where the patient s appetite will be stimulated The diet should be varied well balanced and not too fattening. Another important reason is that he will be nursed by a staff trained in the special technique of orthopædic nursing and in company with other long stay patients. A stay of a year or more in an acute hospital is impractical and demoralizing to the patient who sees others coming and going rapidly while he remains. He must become mentally adjusted to a term of months or years rather than days or weeks. Finally children need organized education, which cannot be provided in an acute hospital.

Antibiotics and Chemotherapy Streptomycin is given by intramuscular injection in an average dose of 1 g. per day or ½ g. for a child. When used in the treatment of tuberculosis it must always be given in conjunction with either para aminosalicylic acid, 12–20 g. or isonicotinic acid hydrazide, 200 mg. by the mouth daily

Streptomycin therapy is always indicated for bone and joint tuberculosis but is specially effective under the following conditions (*a*) in the early hyperæmic stage when the disease is confined mainly to the synovial membrane and before disorganization of the joint has occurred (*b*) when the disease becomes reactivated after a quiescent period and (*c*) as a cover before and after operations, to lessen the risk of miliary spread The patient or his parents should be warned that streptomycin may cause damage to the labyrinth and cochlea.

When the disease has become localized by fibrous tissue and bone sclerosis, there is less likelihood of an adequate concentration of streptomycin at



FIG. 17 19 HEALED TUBERCULOSIS OF THE KNEE JOINT
The articular cartilage has been destroyed and the tibia is eroded on the inner side.

the site of disease and it may be better to inject it locally Streptomycin therapy should be continued for a long period and from six to nine months may be regarded as adequate, although some authorities would consider *eighteen months more suitable There is evidence that*, in the past, the period of treatment has been too short. Watch must be kept for signs of toxicity of which deafness and giddiness are the chief ones.

Local Treatment The objects to be achieved are

(1) To provide rest to the joint, if possible by continuous traction so that inflamed surfaces are separated, pain reduced and muscle spasm diminished It follows that disease of the spine and lower limb must be treated in bed.

(2) To prevent deformity by immobilization of the limb in a position of function lest fibrous ankylosis should occur

(3) To correct deformity if already present, by gradual traction into the optimum position on no account should force be used and manipulation has no place in the treatment of joint tuberculosis.

(4) To continue immobilization until there is clinical and radiological evidence of healing.

It may be difficult to decide at what point to stop treatment, and when doubt exists it is wise to continue for a further period. In general, the patient should be feeling well, with a steady weight, normal temperature and pulse chart. Locally the joint should be cool swelling absent and movement pain less. The presence of muscle spasm on movement may be taken to indicate continued activity The E.S R. should be normal

Radiological Signs of Healing There should be no further progress of the disease in films taken at intervals of two to three months (Fig. 17 19). The decalcified bone becomes more dense and is surrounded by sclerosed bone. Abscesses may be seen to calcify A firm fibrous ankylosis may be a safe joint but an unstable ankylosis is probably not. In either case conversion to bony ankylosis by operation may be desirable. The outcome of synovial tuberculosis treated early may well be a joint with a near-normal range of movement

Operative Treatment. With the exception of diagnostic aspiration or biopsy this should not be undertaken until the patient has had several months conservative treatment. The object is to build up the general resistance of the body and to allow local inflammatory reaction to settle down. The use of streptomycin and chemotherapy makes operative treatment possible at an earlier stage and with greater safety

The ideal operation is to remove the diseased area entirely but apart from amputation this is rarely possible. Nevertheless a radical approach, with the idea of removing as much tuberculous tissue as possible, together with the surrounding barrier of fibrous tissue or bone, will allow new blood vessels to invade the area and promote healing. A direct attack is made on bone foci, which are curetted to remove débris and sequestra joints may be subjected to arthrotomy with the removal of portions of synovial membrane. With continued conservative treatment under favourable conditions, healing may be expected in about a year instead of the four or five years often necessary with conservative treatment alone.

The types of operative treatment, apart from diagnostic aspiration of fluid or biopsy of synovial membrane, and the indications for their use are as follows

Erasure Curettage of diseased tissue is followed by splinting. Fibrous ankylosis is to be expected.

Excision. This is more radical and the aim is to remove all diseased tissue and a margin of healthy bone. It is not suitable in children because of interference with growth by damage to the epiphyseal cartilage. Excision is used in the elbow to produce a mobile joint or pseudarthrosis. In the knee the aim is that of a bony ankylosis for stability

Arthrodesis This is used in the late stages of the disease when healing or quiescence has been achieved by conservative treatment, combined perhaps with curettage. The object is to convert a fibrous ankylosis to ankylosis by bone. It may be combined with an osteotomy to correct deformity and

is chiefly used in the hip joint. The graft is placed some distance away from the diseased bone (extra articular arthrodesis). The operation of arthrodesis is applicable to any joint (e g shoulder).

Amputation This is indicated in middle-aged patients whose response to tuberculous infection is poor, or in cases where gross secondary infection has occurred. Amputation of the upper limb should obviously be avoided wherever possible, but with a tuberculous ankle or knee amputation is to be preferred to a long period of treatment in the middle aged.

Complications of Tuberculous Joints. These may be considered under two headings

Complications of the Disease Abscess formation may lead to sinuses, secondary infection and amyloid disease.

Disorganization of the joint results in fibrous ankylosis. This may be firm or unstable. In either case the disease may become reactivated at a later date, and deformity may occur because of muscle pull. The best example of this is to be seen in the hip which at the end of conservative treatment may be in good position. A few years later it becomes flexed and adducted by the pull of the psoas and adductor muscles. Correction by osteotomy and arthrodesis is then desirable.

Complications of Treatment Certain complications may result from prolonged rest in bed. Examples are

Renal calculi The predisposing causes are (*a*) The supine position which favours stagnation of urine in the renal calyces (*b*) Immobilization which favours bone decalcification, the calcium of which is lost in the urine (*c*) Dehydration, usually the result of exposure to too much direct sunshine and (*d*) Urinary infection. The methods of prevention are frequent change of position, plenty of fluid by mouth and avoidance of overheating the body

Premature fusion of epiphysis. This occurs at the knee in cases of tuberculosis of the hip treated on prolonged traction. The early fusion accounts for much of the shortening in the limb only a small amount of which is due to destruction of the femoral head and neck.

Tuberculous Disease of Special Joints

The Shoulder The shoulder joint is rarely affected in children and not very commonly in adults The disease usually starts in the head of the humerus, subsequently affecting the synovial membrane and perhaps also the glenoid cavity Frequently it results in ankylosis without suppuration (*caries sicca*) (Fig. 17 20) Effusion with the formation of melon-seed bodies is sometimes observed. If abscesses develop they are likely to point either in front of or behind the deltoid, in the former case extending along the synovial membrane lining the bicipital groove. The ultimate result is usually ankylosis, with perhaps shortening of the arm or some forward displacement of the upper end of the bone simulating a subcoracoid dislocation.

Treatment The only satisfactory method of rest is by a plaster spica including the thorax and upper limb The arm is fixed in 70 degrees of abduction and 15 degrees of forward flexion in the coronal plane. Progress may be slow and operation is often required Curettage followed by bone grafting should lead to a satisfactory bony arthrodesis.

The Elbow In the elbow joint the disease is most common in young adults, commencing usually in the synovial membrane especially that of the superior radio-ulnar articulation The swollen synovial membrane bulges



FIG. 17 20 CARIES SICCA OF THE SHOULDER JOINT SHOWING EROSION OF THE HUMERUS AND DESTRUCTION OF THE JOINT

on either side of the olecranon and tendon of the biceps, and can often be felt over the head of the radius the joint presents the typical appearance of a "white swelling." Abscesses form by the side of the olecranon or may



FIG 17 21 DESTRUCTION OF THE ELBOW JOINT BY TUBERCULOSIS. Calcified abscesses can be seen on both sides.

burrow upwards along the ulnar nerve and open on the inner aspect of the arm. These may undergo calcification (Fig. 17 21)

Treatment Immobilization should be in plaster with the elbow at 90 degrees. In children, conservative treatment should be continued. Ankylosis is likely In adults an excision of the joint may be undertaken with the idea of obtaining a mobile joint.

The Wrist. In the wrist diffuse disease of the synovial membrane and bones is seen, starting most frequently from the former structure. If primarily bony it usually starts in the lower end of the radius. It may also extend from



FIG. 17 22. ADVANCED TUBERCULOUS ARTHRITIS OF THE WRIST JOINT

a tuberculous affection of the adjacent tendon sheaths. A characteristic doughy swelling forms over the dorsum displacing the extensor tendons, while the palmar aspect of the wrist is also puffy and the hand itself is slightly flexed. The movements of the fingers are impaired by adhesions. Sinuses develop most frequently on the dorsal aspect or by the side of the flexor carpi radialis tendon (Fig. 17 22). Tuberculous tenosynovitis is described in Chapter 10.

Treatment Conservative treatment, with the wrist dorsiflexed, may bring about a cure, and every effort should be made to avoid radical operative treatment. Curettage is sometimes useful.

The Knee. The knee joint is a common site for tuberculous disease, which may start in either synovial membrane or bone. When synovial, spread to bone with typical radiological changes may be late in the disease and early diagnosis may be difficult. The history is that of a chronic swelling confined to one joint, arising insidiously but with perhaps a history of injury some weeks previously The knee becomes swollen, warm and uncomfortable with some limitation of movement. Pain is often minimal.

Diagnosis On examination the swelling is confined mainly to the synovial membrane with little effusion into the joint. Enlarged inguinal lymph nodes

may be present and biopsy of one of these may yield a positive result. Radiography may be negative or show slight generalized decalcification unless there is a primary focus in bone. Differential diagnosis must include trauma, subacute infection, Still's disease, hæmophilia and congenital syphilis, while in adults, rheumatoid and osteo-arthritis must be added

Treatment The preliminary treatment must be provisional, as in the case of the hip joint Rest on a Thomas's splint with light skin traction allows easy access to the joint for diagnostic purposes. Direct biopsy of the synovial membrane may be permissible under streptomycin cover



FIG. 17 23 TUBERCULOUS DISEASE OF THE KNEE JOINT
The articular cartilage is fully destroyed and the bone beneath is eroded.

When the diagnosis is established, immobilization in a plaster of Paris spica may be substituted for the splint, and when walking is allowed the knee must be protected by a caliper for several months. The aim of treatment should be a mobile joint, but bone destruction may result in a fibrous ankylosis In adults, when growth has ceased it is better to excise the joint in order to obtain a sound bony ankylosis.

In the elderly or when sinuses and secondary infection has occurred, amputation through the thigh may be the wisest course to adopt.

The Ankle. Tuberculous disease of this joint usually starts in the synovial membrane rather than in the bone The whole region becomes occupied by a pulpy swelling, which first pushes forwards the extensor tendons and bulges in front of the malleoli and subsequently appears on either side of the tendo Achillis. Pain is often slight, and the movements of the ankle may be little impaired the calf muscles are usually wasted. In the later stages, when the bones are involved, the pain increases and the foot is maintained in a position of slight plantar flexion, so as to bring the narrower portion of the upper surface of the talus into the tibiofibular mortice. Flexion and extension of the foot are usually limited or lost, but with care the lateral movements (inversion and eversion) which occur at the midtarsal and subtaloid joints can be undertaken without pain. If the disease is primarily osseous, localized painful areas occur over the lower ends of the tibia and fibula, or over the talus, and these can be demonstrated by radiography In either type, abscess formation is very liable to follow and may become extensive owing to the involvement of tendon sheaths.

Treatment In the early stages, prolonged rest and immobilization in plaster of Paris are required This may be followed by arthrodesis. When the

disease remains active in spite of conservative treatment arthrotomy can be undertaken, but removal of the talus and of all available synovial membrane is probably a better course to adopt. When the disease also involves the tibia and fibula, a below knee amputation will probably be necessary

The Bones and Joints of the Foot. Tuberculous osteitis as it affects the foot is described earlier in this chapter

Tuberculous Disease of the Hip

The hip joint and the spine are the commonest sites for skeletal tuberculosis. The hip affection is usually a disease of childhood but may also be encountered in adolescents and adults, the trend being towards the older age groups in recent years.

Ætiology The general pathology corresponds with that found in other joints, but owing to the anatomy of the hip certain points must be noted.

The primary focus may be in synovial membrane or in bone, and the disease therefore may start in the floor of the acetabulum or femoral head or neck (Fig. 17 24) The joint being of the tight fitting ball-and-socket variety

FIG. 17 24 THE COMMON SITES IN WHICH *TUBERCULOUS DISEASE OF THE HIP-JOINT MAY ARISE.*
1 Acetabular 2. epiphyseal 3 juxta-epiphyseal, 4. subtrochanteric (extra-articular focus).

FIG 17 25 A TUBERCULOUS FEMUR WITH A SEQUESTRUM LYING IN AN ABSCESS CAVITY (*Royal College of Surgeons Museum.*)
The condition was of old standing as evidenced by the absorption of the head, the destruction of the joint cavity and the sclerosis in the bone which surrounds the sequestral cavity

débris and caseous material can collect under tension until relieved by rupture of the capsule An abscess may be found in the pelvis arising from the acetabular floor and in this situation will lie beneath the obturator internus muscle and may be felt on rectal examination. [illegible] bscess may track into the ischiorectal fo[illegible] bscesses bursting [illegible] oint capsule may point in the inguin[illegible] the inner side o[illegible] or posteriorly at the lower border [illegible] maximus. Ra[illegible] ic bone abscess may be found by r[illegible] e neck of the [illegible]
When the joint b[illegible] nized there [illegible] for the [illegible] head to subluxate fr[illegible] um because [illegible]
Some new bone form[illegible] at a highe[illegible]

the socket becomes shallow This condition is known as a "travelling acetabulum" (Fig 17.26) Subluxation together with destruction of the femoral head and neck causes shortening of the limb but as already mentioned, much of the shortening may be due to premature fusion of the lower femoral epiphysis. Healing is by fibrous tissue and the resulting ankylosis may be unsound. After a few years, considerable deformity may occur



FIG 17 26. FEMUR AND ACETABULUM IN TUBERCULOUS DISEASE OF THE HIP (*King's College Hospital Museum.*)
The epiphysis of the femur has been practically destroyed, and the acetabulum is enlarged by absorption of its posterior margin and displaced upwards (travelling acetabulum) The rami of the ischium and pubes have been removed.



FIG 17 27 EARLY STAGE OF TUBERCULOUS DISEASE OF THE LEFT HIP IN A CHILD.
The black line is drawn from one anterior superior spine to the other, and shows not only the amount of abduction present, but also the tilting down of the pelvis on the affected side.

although at the time of discharge from hospital the limb may have been in an excellent position. The late deformity is one of flexion and adduction which further increases the shortening of the limb (Fig. 17 28) It is caused by the action of the corresponding muscles whose power is greater than that of their opponents.

History Although the term "hip joint disease" or "coxalgia" is usually applied to a tuberculous arthritis, the diagnosis of an early arthritis of the hip may present difficulties. The patients are commonly children and it is important to realize that the history and early signs may be almost identical in a number of conditions of differing pathology

The history is that of a child who has a painful limp This may be intermittent and observed over a period of weeks. The pain may be referred to the knee because femoral, sciatic and obturator nerves supply branches to both joints. A painful knee without obvious local cause should excite suspicion of hip disease, and the spine should be examined in every case. There may be a history of injury but this is not always so Occasionally "night starts" may be present.

This kind of history should arouse suspicion of the following (*a*) Traumatic arthritis, (*b*) Infective arthritis, (*c*) Tuberculous arthritis, or (*d*) Pseudo-coxalgia. The differential diagnosis will be discussed later

Examination of the Hip Joint. The patient should be completely undressed, and if possible should be asked to walk so that the gait may be observed The examination is then continued with the patient lying flat on a couch, at first supine, then prone. It is well to proceed in an orderly manner as follows

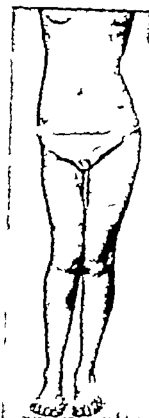


FIG. 17 28. ADVANCED TUBERCULOSIS OF THE RIGHT HIP

This has been allowed to ankylose in too much abduction. The pelvis is tilted and there is apparent shortening of the sound leg.

The Position of the Limb Deformity is noted and may be in three planes.

(1) Flexion deformity Flexion to 25 degrees can be masked by pelvic tilt, and this is shown by lumbar lordosis (Fig. 17 29). When the sound leg is flexed fully on to the abdomen, the pelvis is rotated and the lumbar spine flattened (Fig. 17 30) At the same time the diseased hip will flex and the amount of this may be noted in degrees. This is Thomas s hip test.

(2) Abduction-adduction deformity Minor degrees may be masked by pelvic tilt in the horizontal plane (Fig. 17 31). Abduction deformity will be compensated by a downward tilt of the pelvis and cause apparent lengthening of the limb. Adduction deformity will be compensated by an upward tilt of the pelvis and cause apparent shortening of the limb. This is conveniently determined with a tape-measure from the xiphisternum to the medial malleolus on each limb.

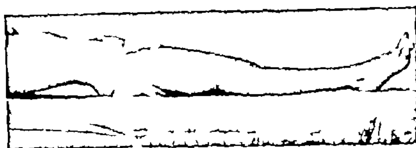


Fig. 17 29. Tuberculosis of the Hip
Fixed flexion masked by lordosis.

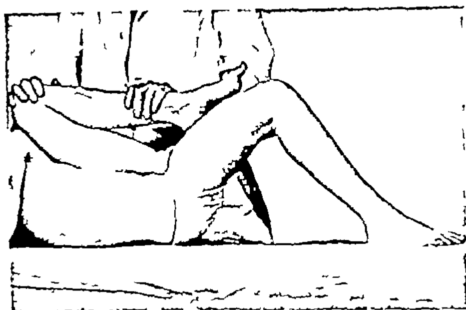


Fig. 17 30. Tuberculosis of the Hip
The lordosis is flattened out by flexing the sound hip on to the abdomen. Fixed flexion becomes apparent in the diseased hip (Thomas's hip test)

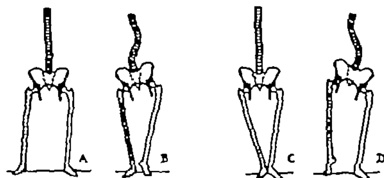


Fig. 17 31 Diagram to Illustrate the Positions Assumed by the Limb in the Early and Late Stages of Tuberculosis of the Hip

A represents the position of abduction taken by the right limb in the early stages of hip disease, and B, Nature's method of masking this by tilting the pelvis down on the affected side, while the other leg is adducted the effect of this on the spine, in causing a lateral deflection, is also indicated. C shows the same thing in the later stage, when adduction is present and the pelvis is tilted upwards on the affected side, thus *producing* apparent shortening, D

(3) Rotational deformity Lateral, or less commonly medial, rotation is easily seen by noting the direction in which the patella is pointing.

The early stage of inflammation in the hip is characterized by flexion, abduction and lateral rotation. In the later stages of disease in untreated joints the limb will assume a position of flexion, adduction and medial rotation.

Swelling There may be fullness in the groin or in the hollow behind the greater trochanter The head of the femur may be tender when pressure is exerted in the groin.

Muscles Muscle *wasting* is rapid and comparison of the girth of the two thighs should be made by measurement. With the patient prone, the buttock may appear flattened and the gluteal fold lost.

Muscle *spasm* is a sign of inflammation. Spasm prevents painful movement, and may be observed when the joint is moved A delicate test for spasm was described by Sir Henry Gauvain as follows "If the femur on the affected side be grasped firmly in the region of the condyles, it will be found that the head of the bone may be gently rotated within the acetabulum, either inward or outward, through a varying but often considerable angle. At the point where this movement is checked a further slight sharp rotation is instantly followed, if the disease is still active, by spasmodic muscular contraction, not confined to muscles about the joint, but extending to the abdomen and visible in the abdominal muscles, or still more easily demonstrated if the palm of the hand is placed on the abdomen between the iliac spines. Quite a gentle and painless, but sharp rotary movement is sufficient to provoke this reflex spasm of the abdominal muscles. Failure to elicit it does not necessarily imply that there is no active disease, but its presence certainly indicates an active lesion.

Lymph Nodes Examination of the iliac fossa may reveal enlarged lymph nodes along the external iliac vessels.

Radiography When the disease is synovial, the earliest change will be one of decalcification when there is a primary bone focus, local destruction without bone reaction is characteristic. Tomography is of value in estimating the size of bone cavities The joint space may be narrowed, indicating destruction of articular cartilage (Fig. 17 18)

The Signs of Advanced Disease. There may be obvious deformity including true shortening of the limb Shortening due to bone destruction will be in the femoral neck. The clinical sign of a short femoral neck is that of a raised trochanter The level of the trochanter is estimated by one of three tests (*a*) a line is drawn between the anterior superior spines and another between the tip of the great trochanters. If one trochanter is raised, the lines will not be parallel (*b*) the tip of the trochanter should lie on Nélaton's Line drawn from the anterior superior spine to the *tuber ischii* (*c*) Bryant's triangle is constructed by a perpendicular dropped from the anterior-superior spine, a line drawn from the spine to the trochanter and a base drawn from the perpendicular to the trochanter The length of the base should be equal on each side of the body In a normal adult it is about 2½ inches (6 cm.)

Another sign of advanced disease is abscess formation. Radiographic appearances will be those of bone destruction with sclerosis indicating healing and sometimes the calcification of abscesses.

Differential Diagnosis in Children. *Trauma or Mild Infection* This is

known as *transient arthritis* because it clears up with a few weeks rest The patient soon loses all pain and restriction of movement and may be allowed up as soon as muscle spasm is absent for a few days. He must however be seen again in six weeks because some cases of pseudo-coxalgia behave in this way Moreover early radiological signs of pseudo-coxalgia are lacking and may not be evident for several weeks

Pseudo-coxalgia This condition is described later but since it is one of the commonest diseases which need to be distinguished from tuberculosis it is convenient to compare them here. The clinical signs may be those of a subacute arthritis, but often they are less marked, being limited to slight muscle spasm with limitation of abduction and medial rotation.

The final diagnosis rests upon the skiagram. It is useful to contrast the early radiological signs of pseudo-coxalgia with those of tuberculosis or infection.

Pseudo-coxalgia	*Tuberculosis*
Increased density of epiphysis.	Generalized osteoporosis of surrounding bone.
Joint space appears widened	Joint space normal or diminished.
Flattening of femoral head.	Normal contour until destruction takes place

Suppurative Arthritis The onset is sudden, pyrexia and general disturbance marked Aspiration of the joint will usually reveal the diagnosis.

Syphilitic Epiphysitis In small babies this may simulate tuberculous disease. There may be other signs of congenital syphilis.

It is to be noted that the limp of congenital dislocation of the hip is not painful in childhood.

Differential Diagnosis in Adolescents and Adults. *The four conditions* which should be considered are (*a*) Adolescent coxa vara of gradual onset, (*b*) Ischaemic necrosis of the femoral head (*c*) Rheumatoid arthritis (monarticular stage), and (*d*) Osteoarthritis.

Prognosis. The prognosis is better in synovial disease than when the primary focus is in bone. If there is no bone destruction a mobile joint is a possible outcome and should be the aim of treatment, but if destruction has occurred, an ankylosis is inevitable

Treatment. The treatment of hip disease follows the usual plan for dealing with tuberculous lesions. The general treatment of the patient should be in a long-stay hospital.

Treatment by Extension. Locally prolonged rest and extension are essential although modifications may be introduced as treatment proceeds Any deformity present must be gradually corrected and the possibility of its development or increase during treatment must not be forgotten. The means of rest and extension now generally employed is the Jones's abduction frame. This consists of a padded metal frame provided with leg pieces which can be adjusted to varying degrees of abduction. Skin traction is used and the tapes from this are tied to the ends of the leg pieces or weight extension may be used if desired If there is at first marked deformity the leg has extension applied in that direction, but before long, if the extension is effective, it will be possible to place the limb in a good position. The relations of the limb to the pelvis must be carefully watched throughout treatment or an unsuspected adduction may develop

Where these appliances are not available, all that is requisite may be secured by weight extension to the affected limb and the application of a

Liston's splint to the sound side. The extension strapping must always be carried well above the knee, so as not to damage the ligaments of that joint, and only enough weight must be used to relieve muscle spasm. In the case of a child this is about 6 pounds (3 kg.) If the amount of flexion is slight, the limb may be allowed to lie on the bed in a horizontal posture: this will probably induce some compensatory *lordosis*, but as the spasm decreases the curvature of the spine disappears.

When the disease has become quiescent as indicated by the absence of pain and muscle spasm, immobilization may be continued in a plaster of Paris hip spica, for perhaps a year or more, but the time will depend upon the amount of bone destruction. With *purely synovial disease*, active movement may be allowed after about nine months and weight bearing at a year but when caries has disorganized the joint, protection must continue until ankylosis has taken place. The patient may be allowed to get about on crutches, while still in plaster or while wearing a caliper. The decision to discontinue immobilization must depend upon general and local signs of healing. Arthrodesis of the joint may be necessary before all splinting is abandoned, except in children under the age of ten years.



A



B

FIG 17 32. TUBERCULOSIS OF THE HIP

A. A tuberculous hip, showing activity after many months of conservation treatment. B. An ischiofemoral arthrodesis has been performed. Fourteen months later the disease is healing.

Operative Treatment. Arthrodesis is the treatment of choice. On account of the prolonged period of immobilization necessary for the cure of this disease, extra-articular arthrodesis after an initial period of extension to relieve the acute symptoms and to diminish the deformity has been advocated. Where there is necrosis of the head of the femur and evidence of fragmentation of bone in the joint, a mixed intra- and extra-articular operation is the best. A period of immobilization in plaster will be required following the operation but the time required for the cure of the disease is about half that of the more conservative procedures. In young children conservative treatment should always be employed.

In iliofemoral arthrodesis the graft is laid between the ilium and greater trochanter. The ischiofemoral type introduced by Brittain is indicated when there is a deformity to correct or where the disease extends into the ilium

above the acetabulum or into the trochanter The graft is taken from the cortex of the tibia. A subtrochanteric osteotomy allows correction of the deformity and the graft is laid between the cut surfaces and driven into the ischium The femoral shaft should be displaced inwards to support it (Fig. 17 32).

Other forms of operative treatment include biopsy of synovial membrane, aspiration of abscesses and when sinus formation has led to heavy secondary infection, excision and curettage may be necessary Arthroplasty should not be attempted on a tuberculous joint owing to the danger of lighting up the disease.

Tuberculous Disease of the Spine

The first accurate description of this disease was made by Percival Pott in 1779 Hence the alternative name Pott s disease or spinal caries. It is the vertebral bodies which are usually affected. Disease of the accessory processes is uncommon As in other skeletal tuberculosis, the infection is blood borne, and occurs most frequently in the age groups one to ten years, and twenty to thirty years. The disease may however arise at any age and is equally distributed between the sexes. While any part of the spinal column may be involved, it is seen typically at certain sites, namely (*a*) The thoracic spine. This is the commonest site and the midthoracic region is usually involved (*b*) The thoracolumbar junction and lumbar spine This is the



FIG 17 33 ANGULAR KYPHOSIS CAUSED BY TUBERCULOSIS OF TWO THORACIC VERTEBRAE AND THE INTERVENING DISC



FIG 17 34 TUBERCULOUS DISEASE OF THE SPINE, SHOWING DESTRUCTION OF THE BODIES OF THE VERTEBRAE AND ABSCESS FORMATION BENEATH THE ANTERIOR LIGAMENT

second most common site, and (c) The cervical spine. This is less commonly affected than the others and then usually in children. When the atlas or axis are the site of disease the laminæ are attacked rather than the bodies of the vertebræ

Pathology The primary lesion is usually in the bone and situated in front of the vertebral body beneath the upper or lower epiphyseal plate. Typically at least two bodies are involved together with the intervertebral disc between. The destruction of the disc is a most important diagnostic point when viewing a skiagram As the disease advances, the intervertebral discs are destroyed and the carious bone collapses beneath the compressing forces exerted by body weight and respiratory movement. The wedge-shaped bodies thus produced combine to form the typical angular kyphosis or gibbus (Fig 17 33)

Occasionally the disease may start as a subperiosteal focus beneath the anterior ligament and may spread up and down the spine, eroding the front of the vertebræ and destroying the discs (Fig. 17 34)

A third variation is seen as a central destruction of the vertebral bodies together with the intervening disc, but without collapse or periosteal involvement. This type is most often seen in the lumbar region (Fig. 17 35). In a few instances, many vertebræ may be attacked at the same time.

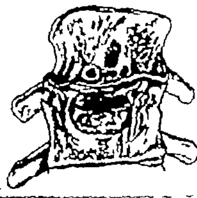


FIG. 17 35 TUBERCULOUS DISEASE OF TWO LUMBAR VERTEBRÆ, SHOWING SEQUESTRUM ON THE ANTERIOR ASPECT AND LATERAL THICKENING PREVENTING ANGULAR DEFORMITY

Sequestra formation is more common than might be thought from the radiological appearances, and may often be found when a direct surgical attack is made upon the area of disease Abscess formation may lead to special complications according to the level of the lesion while the close proximity of the spinal cord introduces the possibility of cord compression and paraplegia.

Healing is by fibrosis as in other parts of the skeleton and this is aided by the vertebral collapse which helps to obliterate the cavity produced by caries (Fig. 17 36) Only in the late stages may new bone formation occur

Signs and Symptoms. A case of Pott s disease may present in one of five ways (a) pain, (b) rigidity (c) deformity (d) abscess formation, or (e) neurological signs These also constitute the typical signs and symptoms.

Pain This is almost invariably present but may be so slight as to escape notice The patient may complain of " rheumatism " and it is a fact that

many cases of Pott's disease have been treated for neuritis, fibrositis or lumbago during the early stages, so insidious is the onset

The pain is of two main types, local and referred *Local pain is often* not severe, but can usually be elicited by pressure or percussion over the spine or perhaps more effectually by pressing upon the transverse processes so as to induce rotation of the vertebral bodies one on another Movements of the spine, bending or twisting, are similarly painful while the same result can be brought about by jarring the spine as by a blow on the head or buttocks. *Referred pain* is produced by pressure upon, or irritation of the



FIG. 17 36. HEALED TUBERCULOUS DISEASE OF THE SPINE.

roots of the nerves as they emerge from the intervertebral foramina consequently its distribution is governed by the arrangement of the nerve-root area of the affected spinal segment.

If the cervical region is affected the pain may be referred down the arms in the thoracic region it may follow the intercostal nerves and is called "girdle pain" In the lumbar region it may follow the sciatic, obturator or femoral nerves.

Rigidity Rigidity of the spine in the early stages results from muscle spasm, and later from ankylosis of the affected vertebræ.

Muscle spasm is protective and may be readily seen when the patient is asked to stoop and to pick up an object from the floor The back is held rigid and stooping is accomplished by flexing the knees and hips. On rising to the erect posture the trunk is supported by resting the hands on the thighs.

In a child, lumbar rigidity can be demonstrated when lying prone. The

ankles are grasped and the legs lifted from the table and moved from side to side. Normally a considerable degree of hyperextension and lateral mobility is possible

Deformity The characteristic deformity is that of an angular kyphosis or gibbus. This may be seen only as a slight prominence of a spinous process, or it may be quite marked, depending upon the number of vertebral bodies which have collapsed (Fig 17 37). The deformity should be compared with the round back of Scheuermann's disease (Fig. 11 11)



FIG 17 37 KYPHOSIS FROM TUBERCULOUS DISEASE OF THE LOWER THORACIC VERTEBRÆ.
The disease was quiescent although the patient had not rested in bed. Several vertebræ are involved. An abscess is visible and is pointing behind the great trochanter

In the lumbar region and to a lesser extent in the cervical region, loss of the normal forward convexity is to be observed the lumbar spine loses its lordosis and appears flattened Slight lateral curvature may result when there is destruction of the sides of the vertebral bodies, but scoliosis is never marked in Pott's disease.

When in childhood, gross destruction has occurred in the thoracic spine, the whole thoracic cage becomes distorted. The sternum is pushed forwards and the ribs crowded together The patient, although by now an adult, is of stunted growth and presents the typical picture of a "hunch-back dwarf"

Abscess Formation This may attain a considerable size before it is recognized The pus collects on the anterior aspect of the vertebræ, beneath the anterior ligament, which is stripped from the bone for a considerable distance The abscess enlarges laterally and may be seen in a skiagram as a spindle-shaped shadow surrounding the vertebræ. Spread may then take place in various directions according to the local anatomy

In the cervical region a chronic retropharyngeal abscess may form behind the prevertebral layer of the deep cervical fascia. It bulges into the posterior

pharyngeal wall and may be seen from the mouth The pus tends to track laterally behind this layer of fascia and to appear at the side of the neck behind the sternomastoid muscle where it forms a lateral cervical abscess.

In the thoracic region the abscess usually remains as a posterior mediastinal abscess, visible only in a skiagram (Fig. 17 38) It may track along an intercostal space and appear on the surface, at the point of perforation of a lateral cutaneous nerve (Fig. 17 39) Close proximity to the pleural cavity



FIG. 17 38 TUBERCULOUS PARAVERTEBRAL ABSCESS IN THE LOWER THORACIC REGION.



FIG. 17 39 TUBERCULOUS ABSCESS WHICH HAS TRACKED ALONG AN INTERCOSTAL SPACE.

The disease involved the fifth and sixth thoracic vertebræ.

may cause a pleural effusion Rarely the abscess may burst into the lung and track through the diaphragm to form a chronic perinephric abscess.

In the lumbar region the pus enters the psoas sheath to form a psoas abscess, which may be felt as an elongated swelling in the iliac fossa. If large, it may track under the inguinal ligament and in this case fluctuation may be detected above and below it (Figs. 17 40 and 41) Flexion of the hip may indicate that the psoas muscle is in spasm.

Alternatively the pus may collect beneath the iliac muscle forming an iliac abscess. The pus may also pass backward through the lumbar triangle to point as a lumbar abscess above the iliac crest. In disease of the lower lumbar vertebræ, the pus may flow over the brim of the pelvis and point either as a chronic ischiorectal abscess or pass onwards through the sciatic notch along the course of the pyriformis muscle. It then points behind the great trochanter (Fig. 17 37)

If an abscess becomes so large that it bursts through the skin, a sinus is formed Secondary infection is likely and this may lead to the most serious consequences. In the late stages of the disease abscesses may calcify (Fig. 17 42)

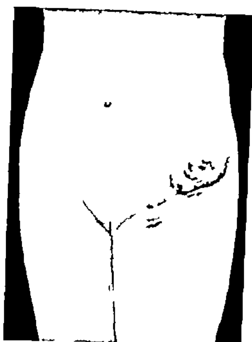


FIG. 17 40. PSOAS ABSCESS POINTING IN THE ILIAC FOSSA AND BURROWING AMONG THE ADDUCTOR MUSCLES.

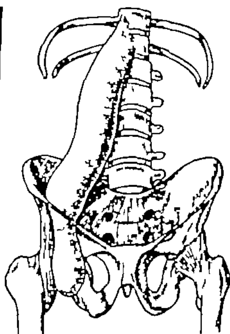


FIG. 17 41 PSOAS ABSCESS IN RELATION TO THE SPINE AND PELVIS.



FIG. 17 42. BILATERAL CALCIFIED PSOAS ABSCESSES.

Neurological Symptoms These are due to involvement of either the nerve roots, which gives rise to referred pain or of the spinal cord with resulting paraplegia

Paraplegia occurs in about 10 per cent of all cases of tuberculosis of the spine Thoracic disease is usually responsible The pressure on the cord may be due to trauma in which case the paraplegia is transient and clears up rapidly with rest. More severe paraplegia may be caused by the pressure of an abscess or by tuberculous granulation tissue while in some cases a sequestrum is responsible In the late stages of this disease, paraplegia may result from extreme angulation of the spine or from a pathological fracture-dislocation The onset of paraplegia may be sudden or gradual the latter being the more common

The first symptoms may be those of slight spasticity dragging of the feet on walking with increasing weakness of the legs. As the cord pressure increases, anæsthesia and loss of sphincter control may develop This type of paraplegia produces spasticity with painful flexor spasms, increased reflexes and extensor responses. Flaccid paralysis, from sudden cord compression may be encountered rarely

Radiological Changes. Symptoms of the disease may of course, be present before any changes are seen in a skiagram. The earliest signs are those of bone destruction without new bone formation *i.e* local rarefaction At least two vertebral bodies are involved together with the intervening disc space, which is narrowed An abscess shadow may be visible at an early stage.

Two other conditions may cause collapse of vertebral bodies. These are a wedge fracture or a neoplasm. In a wedge fracture the main damage will be to the bone, and the same holds good for a neoplasm, which invades the disc space only late in the disease In these two conditions, therefore, the disc space will appear intact.

Differential Diagnosis. This may be difficult The presence of an undoubted abscess will usually decide the diagnosis, but a fusiform shadow seen in a skiagram may in fact, be neoplastic. The following conditions should be considered

Osteochondritis This occurs in adolescents. The lesion may be confined to one vertebra, and the disc space may be narrowed. The bone lesion is usually well defined and surrounded by a zone of sclerosis

Neoplasms These are likely to be secondary to carcinoma of the breast, prostate, lung, thyroid or kidney or to multiple myelomatosis. Neoplasms are more likely in patients over the age of forty at which age tuberculosis becomes less common.

Pyogenic Osteomyelitis This is comparatively rare but may simulate tuberculosis in the early stages.

Other Causes These include ankylosing spondylitis, intervertebral disc lesions, osteoarthritis and "lumbago This is a symptom, not a disease and the complaint should be treated with suspicion.

Prognosis. To give a prognosis in a case of Pott's disease is not easy Much depends upon the presence or absence of other active lesions in the body and upon the type and stage of the disease. At the best a year or more of recumbency may be required. It may be very difficult to decide when the disease is quiescent. Reactivation may take place years later with abscess formation or late paraplegia. Tuberculous lesions may appear elsewhere

in the body An apparent cure may take place in a year or two but the long term prognosis must be guarded.

Treatment. Every effort must be made to secure treatment in a long-stay hospital. The aim of local treatment is to obtain healing with a minimum of deformity To this end three essentials are required (*a*) Recumbency (*b*) Immobilization of the spine and (*c*) Prevention of deformity

Immobilization may be secured either on a spinal frame or in a plaster bed (Fig 17 43) In some hospitals the patient merely lies on a hard mattress.

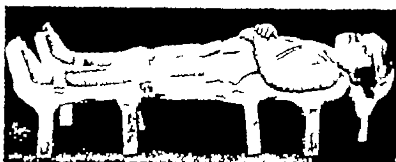


FIG. 17 43 A PLASTER BED.

In children, weight extension may be applied by means of a corset and pelvic band. Suitable provision must be made for turning the patient each week. In the case of plaster beds, this consists of an anterior removable shell.

Early recumbency *is essential to prevent gross deformity* The kyphosis can be pushed forward by padding, inserted in the plaster bed, so that compensatory curves are developed in the spine above and below the deformity On no account *must the area of collapse be opened out, for should this* happen, healing will be delayed

With improvement in the general condition, absence of fever and pain, and normal E.S R., the active phase may be judged to be at an end. This must be confirmed by radiology Films taken at three monthly intervals should reveal no further increase of bone destruction and possibly some increase in bone calcification, indicative of healing. At this stage some relaxation of the régime of strict immobilization may be allowed A *Minerva* plaster (Fig. 17 44) or a spinal brace (Fig. 17 45) may be fitted and the patient allowed to sit in a chair and finally to walk. This protection must be continued for several years Operative treatment may take several forms.

Erasure or Curettage There is a growing tendency in some centres, to advocate an early surgical attack upon the diseased area. After a few months of conservative treatment the vertebræ are exposed under a cover of streptomycin. Diseased bone is curetted away and all sequestra and granulation tissue removed. The wound is closed As in other skeletal tuberculosis, the results of this procedure are often spectacular Healing is more rapid and complete and the patient is able to leave hospital in a shorter time than with conservative treatment alone The method is at present under trial and the long term results are, as yet, unknown.

Spinal Fusion. In adults, the question of a bone-grafting operation may be considered The object is to convert a fibrous into a bony ankylosis. The operation should never be done until there are signs of local healing and until the general condition of the patient is satisfactory "Operate late rather

than early and perhaps not at all should be the motto In children operative fusion of the spine is best avoided The object of the operation is to fuse the spinous processes and laminæ of all the diseased vertebræ. This may be carried out by a variety of methods, of which the Albee graft is perhaps the best known In this operation a tibial graft is implanted on either side of the spinous processes, well away from the area of disease Immobilization must be continued for at least three months after operation



FIG. 17 44. A PLASTER JACKET APPLIED FOR TUBERCULOUS CARIES OF THE UPPER THORACIC SPINE, ILLUSTRATING FIXATION OF HEAD AND NECK BY A COLLAR (MINERVA PLASTER)

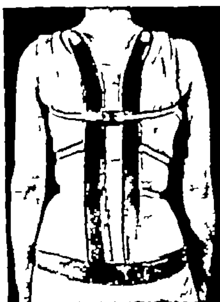


FIG. 17 45 THE TAYLOR SPINAL BRACE.

Treatment of Abscesses These should be aspirated. A large bore needle is necessary and the track should be made as long as possible and in an anti gravity direction to avoid the risk of sinus formation When the contents are too thick for aspiration the abscess may be opened, washed out and the skin closed completely

Evacuation of a paravertebral abscess in the thoracic region is often necessary because of increase in size or because of paraplegia. The abscess is approached by the operation of costotransversectomy A small portion of the posterior end of one rib is removed by subperiosteal resection and the transverse process nibbled away A finger is then inserted around the vertebral body and the pleura pushed forwards until the abscess cavity is

entered The cavity may be approached from both sides of the vertebral column in this way

Treatment of Paraplegia. The general principles of treatment for any form of paraplegia are described in Chapter 25 Pott's paraplegia, arising in the course of tuberculous disease of the spine, may occur early during the active phase of the disease, or later (perhaps months or years later) when the disease is apparently quiescent. Early paraplegia, probably caused by œdema, usually clears up rapidly with conservative treatment, but a tense paravertebral abscess should be evacuated by costotransversectomy

The indications for operative decompression of the cord will depend upon a variety of clinical and radiological factors. The findings upon lumbar puncture and Queckenstedt's test and the protein level in the C.S F will give valuable information with regard to the presence of a spinal block.

Partial motor paralysis has a favourable prognosis, but if it becomes complete, or if there is loss of sensation and of sphincteric control, the prognosis is less favourable Another point of importance is the duration of paraplegia. The longer the pressure persists, the more likely is there to be irreparable damage to the cord Sudden, increasing or complete paraplegia in spite of immobilization calls for decompression Probably two to three months is the maximum period for observation, but the experience and judgment of the surgeon may well be the deciding factor

Antero-lateral decompression is required for adequate decompression of the cord. It is carried out by removal of the posterior ends of two or three ribs and the corresponding transverse processes. Approach to the posterior surface of the vertebral body and the front of the dura is achieved by nibbling away the bone of the pedicle and articular processes, the guide being the nerve root as it issues from the neural foramen. Débris and sequestra may then be removed from the front of the cord *The older* operation of laminectomy is unsuitable for cord pressure arising anterior to the cord, because it does not give access to this area.

The Sacro-iliac Joint. Tuberculous disease of this joint is met with commonly in adults, rarely in children It may start in the synovial membrane or pelvic bones, especially the ilium. The pathology calls for no description as it follows the ordinary course of tuberculous disease.

The onset is insidious and the discovery of an abscess may be the first indication of disease. Pain may vary in severity There may be tenderness on pressure over the joint posteriorly but hyperextension of the leg and compression of the pelvis may not elicit pain.

Skiagrams of the sacro-iliac joint may be difficult to interpret and tomography may be required.

Diagnosis A considerable number of diseases must be considered in differential diagnosis (*a*) Chronic non-tuberculous infection. This may arise by blood-stream spread or directly from an osteomyelitis of the ilium (*b*) Ankylosing spondylitis. This disease is always *bilateral* and the lumbar spine is affected. It is described on page 496 (*c*) Rheumatoid arthritis (*d*) " Sacro-iliac Strain." This is unusual apart from certain fractures of the pelvis in which the joint is also damaged. A diagnosis of sacro-iliac strain after childbirth is rarely tenable, *the pain most often arising in the* lumbosacral joints and (*e*) Neoplasms, usually metastatic. A deposit in the ilium, near the joint, may cause symptoms and signs of sacro-iliac arthritis.

Treatment This is on general lines, including immobilization in a plaster bed. Operative fusion of the joint may be indicated after a few months of conservative treatment On the whole the prognosis is favourable

Backache

The symptom of backache may be brought about by affections of the vertebral column or may originate in structures adjacent to it. For example, a duodenal ulcer perforating into the pancreas may cause severe backache Backache may be caused by injury inflammatory diseases, or growths involving the vertebræ spinal cord or membranes. The deformity of kyphosis and scoliosis may lead to spinal arthritis, while abnormal posture may give rise to pain, originating in ligaments or muscles.

Backache in Children This is unusual but when it occurs, should arouse suspicion of osteochondritis or tuberculosis.

Backache in Adults The type, duration and relation to activity and rest should all be considered Pain relieved by rest or alteration of position suggests a mechanical cause The insidious onset of early tuberculosis may simulate this. Backache continuing over several weeks, or in spite of rest, calls for thorough investigation.

Thoracic Spine. In the absence of obvious deformity disc degeneration, tuberculosis and malignant disease must be considered.

Lumbar Spine. "*Low Back Strain*" This is a common affliction of women The cause in the majority is due to errors of posture, and fatigue associated with child bearing and domestic work. In many radiography will disclose that there are degenerative changes in the fourth and fifth lumbar discs, which may or may not be accompanied by sciatica due to disc protrusions. Correction of posture or the wearing of a firm corset will do much to relieve the symptoms.

Inflammatory Diseases Tuberculous disease or other inflammatory lesions must be excluded In young men, ankylosing spondylitis must always be considered Low backache may be the first symptom before any rigidity of the spine is apparent. The sacro-iliac joints must be radiographed and an E.S R. test done

Malignant Disease In elderly men, metastases from carcinoma of the prostate are common in the lumbar spine. The diagnosis from Paget's disease may be difficult but an acid phosphatase estimation will usually decide the issue, being much raised in the former condition.

Pelvis. The pelvic organs must be examined Unless there is gross disease, continuous backache is unlikely to arise in this situation.

Congenital Abnormalities The lumbosacral region is often the site of congenital abnormalities, for instance spondylolisthesis and sacralization of the fifth lumbar vertebra. In the latter condition the vertebra is "transitional" in type being partly lumbar and partly sacral The transverse process is enlarged on one or both sides and articulates with the iliac crest by a false joint. The functional lumbosacral joint is thus between the fourth and fifth lumbar vertebræ and pain is likely to arise in it rather than in the false joint.

Spina bifida occulta of the first sacral vertebra, though commonly seen in skiagrams, does not cause pain.

Sacro-iliac Joint. Backache may be caused by ankylosing spondylitis, infective arthritis or tuberculosis A provisional diagnosis of "sacro-iliac

strain is seldom confirmed by examination which nearly always suggests that the pain is of lumbosacral origin.

Syphilitic Affections of Bones and Joints

These lesions are now rarely seen in European countries owing to the control of the disease by antibiotics. In places where early control is not possible, bone lesions are still common, and may be caused by congenital or acquired syphilis. Treatment is along general lines, penicillin, arsenical compounds and potassium iodide being the drugs employed.

Syphilis of Bone. Bone lesions occur in the tertiary stage of the disease and may be regarded as a gummatous periostitis or osteitis. The lesions may simulate almost any other bone pathology and the possibility of syphilis



FIG 17 46 SYPHILITIC CARIES OF THE SKULL FROM DIFFUSE GUMMATOUS DISEASE
(King's College Hospital Museum)

should always be considered in the differential diagnosis of doubtful cases. The lesions tend to be multiple and indeed the affection of a single bone makes the diagnosis of syphilis unlikely. There may be additional gummata in the soft tissues.

The lesions respond rapidly to anti-syphilitic treatment and this observation may be a considerable aid in diagnosis. The common complaint is that of pain in the affected limb. Radiography in the early stages reveals areas of rarefaction at the site of bone caries, but sclerosis is the typical finding when healing has occurred.

Yaws may also attack bone, but the compact tissue rather than the periosteum is affected. Scarring and pigmentation of the skin is a diagnostic sign, not present in syphilis. The onset of the disease may sometimes be acute, simulating that of pyogenic osteomyelitis.

Gummatous Periostitis. This may be local or diffuse and new bone is laid down. In the tibia the diffuse variety of the disease may cause an apparent forward curvature of the bone, which has been named "sabre" tibia. A skiagram will show thickening and sclerosis of the cortex.

Gummatous Osteitis. The vault of the skull is a typical site. The gumma may break down and become infected with pyogenic organisms. Most pathological museums contain specimens similar to that depicted in Fig. 17 46 which shows a "worm-eaten" appearance of the bone, produced as much by pyogenic infection and poisoning by mercurial drugs as by the original gumma.

"Parrot's nodes" are areas of subperiosteal new bone formed around

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FIG. 17 46. SYPHILITIC CARIES OF THE SKULL FROM DIFFUSE GUMMATOUS DISEASE. (*King's College Hospital Museum.*)

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"Parrot's nodes" are areas of subperiosteal new bone formed around

the anterior fontanelle in the skull of infants A " hot-cross bun " effect is produced. In craniotabes the vault of the skull becomes thinned by absorption of bone. The thin bone when pressed by the finger gives the characteristic physical sign of " egg shell crackling."

Gumma of the palate may result in necrosis with perforation, and that of the nasal bones may lead to the characteristic nasal discharge known as " snuffles " and later to the depressed nasal bridge characteristic of inherited syphilis.

Syphilitic Epiphysitis This occurs within the first year of life. The disease may be acute in type and the inflammation may spread to the metaphysis. Pain prevents use of the limb which may appear to be paralysed This appearance of pseudo-paralysis is similar to that seen in scurvy The distribution is often symmetrical and the epiphysis may be destroyed or displaced. Secondary infection may supervene and as a result of the disease growth of the limb may be affected

Syphilis of Joints. Joints are less commonly affected than bones. Lesions may occur in the secondary and tertiary stages of the disease

Clutton s Joints The joint is the site of an effusion, usually painless and without signs of inflammation The size of the effusion may vary from day to day and the condition is typically a bilateral affection of the knees, although other joints may be affected Resolution may be expected as treatment of the disease proceeds.

Gummatous Synovitis This is a tertiary lesion and is characterized by a painless synovial swelling with effusion

Chondro-arthritis Virchow described a condition similar to osteoarthritis, in which degenerative changes in the articular cartilage led to erosion over the points of pressure. Pain and eburnation of the underlying bone are found less than in osteoarthritis and marginal osteophytes or " lipping " are absent.

Charcot s Joints A Charcot or neuropathic joint is to be regarded as a degenerative arthritis resulting from the loss of joint sensation. The primary disease is in the central nervous system and may or may not be syphilitic in origin. In the latter case there is no local spirochætal lesion in the joint. Charcot s joints are described more fully in Chapter 18

Chapter 18

NON-INFECTIVE DISEASES OF BONES AND JOINTS

Osteochondritis Juvenilis

This is a condition affecting the epiphysis and is seen therefore in children and adolescents The causation is obscure but the most acceptable explanation would appear to be that of vascular impairment associated with degenerative changes in the epiphysis In support of this theory may be mentioned the changes sometimes seen in the upper femoral epiphysis following reduction of a congenital dislocation of the hip These changes resemble those seen at a later age and called pseudo-coxalgia or Perthes s disease. Similar changes sometimes follow injuries to the epiphysis. Other possible causes of vascular disturbance may be (*a*) repeated strain by the pull of powerful muscles (Schlatter s disease of the tibial tuberosity) or (*b*) embolism or thrombosis of the epiphyseal vessels. Chronic infection has also been blamed though the evidence for this is slight.

Unfortunately many eponymous names are attached to the disease according to the site at which it appears. The more common of these will be described, but it is well to remember that this apparently heterogenous collection of " diseases " can really be grouped under the one heading of osteochondritis juvenilis

Pseudo-coxalgia (*Coxa Plana Legg-Perthes s Disease*) The name pseudo-coxalgia implies that this form of osteochondritis juvenilis simulates coxalgia or tuberculosis of the hip It is only in the early symptoms that similarity exists, and it was not until the advent of radiology that the two conditions were distinguished

The upper femoral epiphysis is affected and passes through a cycle of changes lasting from two to three years. These changes are interpreted in terms of radiology and consist at first of increased density followed by fragmentation of the ossific centre. The epiphysis becomes flattened (coxa plana) and the metaphysis shows areas of rarefaction. The femoral neck thickens and a moderate degree of coxa vara develops. Finally the normal bone texture is restored but usually with permanent distortion of the head and neck.

The cycle of changes may best be explained by interference with the blood supply either by trauma or other causes. This results in an ischaemic necrosis of the epiphysis. In support of the traumatic theory is the fact that similar changes are seen in the epiphysis after reduction of a congenital dislocation of the hip and after trauma to other epiphyses in the body The softened epiphysis can be distorted by the pressure of weight bearing and of muscle tone.

Symptoms and Signs. The disease is most often seen in boys between the ages of three and ten years. It is usually unilateral but occasionally both



FIG. 18 1 PSEUDO-COXALGIA, SHOWING RADIOLOGICAL CHANGE, CONDENSATION OF THE FEMORAL EPIPHYSIS AND APPARENT WIDENING OF THE JOINT SPACE.



FIG. 18 2. PSEUDO-COXALGIA. INTERMEDIATE PHASE. FRAGMENTATION OF EPIPHYSIS.



FIG. 18 3 PSEUDO-COXALGIA. FINAL PHASE. REFORMATION OF EPIPHYSIS.

hips are affected in sequence The first symptoms are intermittent pain and a limp These may clear up after a few days to be repeated in a short time. The pain may be referred to the knee.

Examination At first this may be negative, or the hip may show the early signs common to other types of hip disease These are tenderness in the groin and muscle spasm, which limits the movements of abduction and rotation Flexion is often full.

The earliest change to be seen on radiology is that of condensation of the epiphysis, together with an apparent widening of the joint space. This is because the ossific centre is small and there is more non-ossified carti

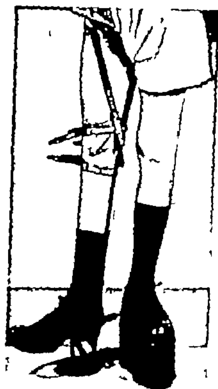


FIG. 18 4 PATTEN-ENDED CALIPERS USED IN THE TREATMENT OF PSEUDO-COXALGIA
The shoe on the normal side is built up to equalize the length of the two legs.

present (Figs. 18 1 to 3) In a few weeks the epiphysis fragments and becomes flattened. After two to three years the fragmented areas coalesce and the normal bone texture is restored, but usually with deformity The differential diagnosis from tuberculosis is important. In Perthes's disease, the joint space is wide, the epiphysis dense and fragmented. In tuberculosis the joint space is narrow and rarefaction is the rule only in the late healing stage is condensation seen.

Treatment There is no treatment known which has any influence upon the sequence of events in the epiphysis. All that can be done is to attempt to prevent deformity during this cycle.

When the hip shows signs of an arthritis, it should be treated by the routine expectant treatment for hip disease *i.e.* bed rest and skin traction. The pain and spasm will disappear within a few weeks. Two courses are then open

(*a*) Traction and immobilization may be continued until the epiphysis has reformed This may involve treatment in a long-stay hospital for as much as two to three years. The time factor may compare unfavourably with that for a tuberculous joint.

(*b*) The child may be allowed to get about on a weight relieving patten-ended caliper This allows walking, living at home and ordinary schooling but no games (Fig. 18 4).

One or other course should be pursued until the skiagram shows consolidation of the epiphysis. At present there is no convincing evidence that prolonged bed rest gives results superior to ambulatory treatment. When deformity has occurred normal function is usual until osteo-arthritic changes appear between the ages of twenty and forty years

Schlatter's Disease This affects the tibial tuberosity and may be bilateral It occurs in children about the age of puberty (the preparatory school age) who are taking vigorous exercise. The child complains of tenderness and swelling of the tuberosity which may feel warm The joint is not affected A skiagram may show that the tongue-shaped epiphysis is fragmented and dense. The condition is self-curing and all that is required is to take the child off games for a few months. Absolute rest is not required

Köhler's Disease affects the tarsal navicular The age of onset is about four to six years. Limp aching or slight tenderness may be noticed by the mother Occasionally some swelling and redness over the bone may be

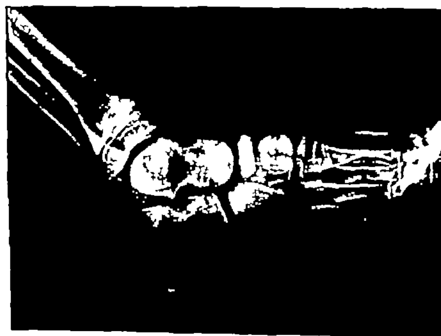


FIG 18 5 KÖHLER'S DISEASE OF THE TARSAL NAVICULAR BONE.

seen. This may arouse the suspicion of tuberculous disease from which Köhler's disease must be distinguished A skiagram shows a flattened bone with increased density (Fig. 18 5) A few weeks immobilization in plaster or freedom from weight bearing will suffice to cure all symptoms and the skiagraphic appearances return to normal in the course of a year or two Slight deformity of the bone may remain.

hips are affected in sequence The first symptoms are intermittent pain and a limp These may clear up after a few days to be repeated in a short time. The pain may be referred to the knee

Examination At first this may be negative, or the hip may show the early signs common to other types of hip disease. These are tenderness in the groin and muscle spasm, which limits the movements of abduction and rotation. Flexion is often full

The earliest change to be seen on radiology is that of condensation of the epiphysis, together with an apparent widening of the joint space. This is because the ossific centre is small and there is more non-ossified cartilage

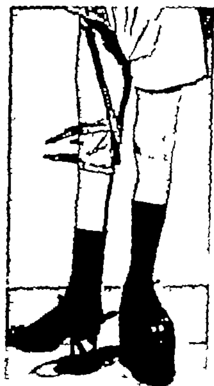


FIG 18 4 PATTEN-ENDED CALIPERS USED IN THE TREATMENT OF PSEUDO-COXALGIA
The shoe on the normal side is built up to equalize the length of the two legs.

present (Figs. 18 1 to 3) In a few weeks the epiphysis fragments and becomes flattened After two to three years the fragmented areas coalesce and the normal bone texture is restored, but usually with deformity The differential diagnosis from tuberculosis is important. In Perthes's disease, the joint space is wide the epiphysis dense and fragmented In tuberculosis the joint space is narrow and rarefaction is the rule only in the late healing stage is condensation seen

Treatment There is no treatment known which has any influence upon the sequence of events in the epiphysis All that can be done is to attempt to prevent deformity during this cycle

When the hip shows signs of an arthritis, it should be treated by the routine expectant treatment for hip disease *i.e* bed rest and skin traction. The pain and spasm will disappear within a few weeks. Two courses are then open

(*a*) Traction and immobilization may be continued unt
has reformed This may involve treatment in a long-stay hosp
as two to three years The time factor may compare unfavo
for a tuberculous joint.

(*b*) The child may be allowed to get about on a weight
ended caliper This allows walking living at home and or
but no games (Fig. 18 4)

One or other course should be pursued until the skiag
solidation of the epiphysis. At present there is no convinci
prolonged bed rest gives results superior to ambulatory tr
deformity has occurred, normal function is usual until osteo-
appear between the ages of twenty and forty years.

Schlatter s Disease This affects the tibial tuberosity and
It occurs in children about the age of puberty (the prepara
who are taking vigorous exercise The child complains of
swelling of the tuberosity which may feel warm. The joint
A skiagram may show that the tongue-shaped epiphysis is
dense The condition is self-curing and all that is required is
off games for a few months. Absolute rest is not required.

Köhler s Disease affects the tarsal navicular The age o
four to six years. Limp aching or slight tenderness may b
mother Occasionally some swelling and redness over th

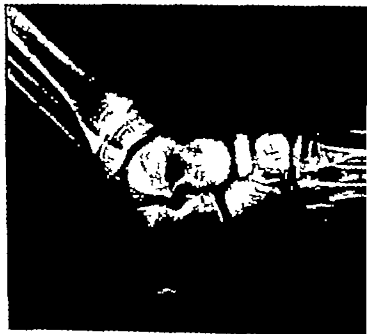


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seen This may arouse the suspicion of tuberculous dise
Köhler s disease must be distinguished. A skiagram shows
with increased density (Fig. 18 5). A few weeks immobiliz
or freedom from weight bearing will suffice to ...

Osgood's Disease. Apophysitis of the calcaneum is another form of osteochondritis The child complains of a painful heel, which is tender on pressure over the epiphysis. There are usually no radiological changes. Pain may be relieved by abstention from games and the wearing of a sorbo rubber cushion in the heel of the shoe

Freiberg's Disease. This is a rare condition affecting the head of a metatarsal, seen in adolescents The changes resemble osteochondritis dissecans of the knee.



FIG. 18 6. KIENBÖCK'S DISEASE OF THE LUNATE BONE

Kienböck's Disease. This affects the lunate bone (Fig. 18 6) and is an avascular necrosis, probably brought about by injury There is a resulting deformity with consequent arthritic changes in the wrist joint.

Scheuermann's Disease. This form of osteochondritis affects the spine. It is also called adolescent kyphosis and is described on p 210

Non-infective Arthritis

The commonest forms of arthritis fall into a group which may be called non infective arthritis. In many cases the ætiology is unknown or only partially known and it is not possible to give a pathological classification. Rather the classification is based upon clinical, morbid anatomical and radiological data. The arthritis is, for the most part, chronic, and the two types most frequently met with are osteo-arthritis and rheumatoid arthritis. In the former the early joint changes fall mostly upon articular cartilage and bone whereas in the latter the synovial membrane is at first attacked. Thus the general terms chondro-osseous and synovial arthritis may be used, *viz* (*a*) *Chondro-osseus* Osteo-arthritis or degenerative arthritis (arthritis deformans) and (*b*) *Synovial* Rheumatoid arthritis or proliferative arthritis.

Osteo-arthritis (Degenerative arthritis)

Ætiology The disease affects primarily the articular cartilage. When one joint only is affected it is likely that there is some local, predisposing cause. When the disease affects many joints it may be regarded as a result of the general wear and tear of life and it is significant that the weight bearing joints of the lower limb are those most commonly affected. Osteo-arthritis of the joints of the upper limb is uncommon except after single or repeated trauma

Monarticular Arthritis This mostly occurs in the lower limb The hip knee or ankle may be affected The local causes may be classified as follows (*a*) Trauma. Fractures into the joint dislocations may be associated with local damage to the articular cartilage but laceration of the capsule which carries blood vessels to the joint may cause ischæmic necrosis of the femoral head This may be followed by osteo-arthritis. The same sequence may be seen after a slipped upper femoral epiphysis (*b*) Disease Previous damage to the joint by sepsis, rheumatoid arthritis or possibly synovial tuberculosis and (*c*) Mechanical factors Deformity of the joint from an old congenital dislocation, pseudocoxalgia or coxa vara. Mal aligned fractures of the shaft of a bone may cause abnormal mechanical stresses leading to osteo-arthritis in the neighbouring joints.

Polyarticular Arthritis This is the arthritis of advancing age and affects mainly the hips and knees. Common in both sexes, the symptoms in women are often associated with the menopause, owing to endocrine disturbances and frequently an increase in weight at that time

Clinical Features. The patient notices a gradual onset of pain in the affected joint, perhaps extending over many years. At first the pain is most marked following a period of rest and is relieved by movements. A typical complaint is that of pain when rising from a chair Later the pain is constant when weight bearing, but relieved by rest In advanced disease, there may be severe pain even when turning over in bed. Gradually the range of movement becomes limited but often not to the same degree in every direction. Deformities may occur in the later stages of the disease and muscle wasting gives a sense of insecurity to the joint.

Radiology The typical changes may be considered under four headings

Bone Density The earliest change seen is a line of sclerosed bone beneath the articular cartilage. Later the bone may appear less dense beneath this line and cystic areas may appear

Osteophyte Formation. Lipping of the joint is characteristic, in contrast to rheumatoid arthritis, in which there is little or no new bone formation at the joint margins.

Joint Space The space appears narrow where the articular cartilage is worn away over the pressure areas.

Deformity This is only seen in advanced disease. The joint may appear subluxated or the alignment distorted (*e g* flexion and adduction of the hip)

Pathology Osteo-arthritis is a disease affecting synovial joints and the primary lesion occurs in the articular cartilage usually at some point most subjected to trauma.

Changes in Articular Cartilage The earliest change consists in the splitting-off of the surface layers and this gives rise to the roughened appearance which has been likened to the " pile on a carpet. Fragments of cartilage may become detached and float away in the synovial fluid but are soon ground up by the movement of the joint. In the deeper layers of cartilage vertical splits appear and the cartilage cells or chondrophytes become clustered on each side, constituting the process of " fibrillation " which is characteristic of the disease.

The softened cartilage next becomes worn away by the grinding action of the joint until the underlying bone is exposed. Concurrently with this process, hyperplasia is taking place at the margin of the cartilage, resulting in the production of irregular outgrowths or chondrophytes. These later

may ossify and then form the osteophytes to be seen in skiagrams taken in the more advanced stages of the disease The osteophytes sometimes attain a considerable size and thus lead to limited movement in the joint. In skiagrams osteophyte formation is referred to as "lipping."

Changes in Bone The subchondral bone becomes hypertrophied and sclerotic. When subjected to friction the sclerotic bone becomes polished, a process called "eburnation." It may be worn into grooves in a hinge joint like the knee or in a circular fashion in the hip joint. Friction of exposed bone surfaces produces the physical sign of coarse crepitus Deep to the



FIG. 18 7 OSTEO-ARTHRITIS OF THE KNEE.
An operative specimen consisting of the lower end of the femur and the upper end of the tibia. Note erosion of the articular cartilage with marginal "lipping" and eburnation of the exposed bone.

zone of sclerosis, cyst-like areas may frequently be seen These are filled with amorphous débris and probably occur during the remodelling process in the bone, but opinions differ as to the exact mode of formation.

Changes in the Capsule At first these are slight, but in advanced osteo-arthritis the capsule becomes much thickened by fibrosis This is the cause of much of the pain and limitation of movement, which is not always consistent with the changes seen in a skiagram

Changes in the Synovial Membrane The synovial membrane is not affected until the disease is advanced but then becomes thickened with some lymphocytic infiltration. The formation of villous processes is sometimes

seen These may contain fat (lipoma arborescens) or occasionally cartilaginous bodies which are pedunculated and may ossify

At operation the synovial membrane may be found adherent to the osteophytes and is hyperæmic, as if in an attempt to take part in the process of repair

Treatment The general health must be considered There is little evidence that septic foci have any direct bearing on the disease, but gross sepsis should be cleared up when possible. The most important factor is weight reduction, which must be achieved by strict dieting. Relief of weight bearing by the use of a walking stick is invaluable, and the patient must learn to " live with his joint " and to restrict his activities accordingly

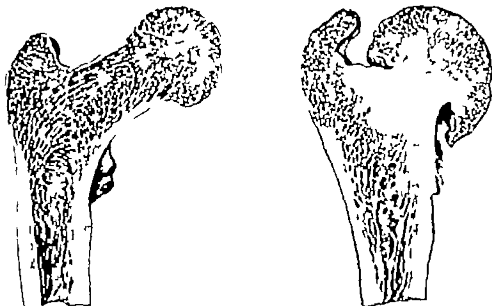


FIG. 18 8. OSTEO-ARTHRITIS OF THE HIP

A normal femur in section has been placed alongside the affected one for comparison the absorption of the neck and the relative elevation of the trochanter are obvious, as also the distortion of the head of the bone.

Physiotherapy and drugs can do much in the early stages of the disease. The three essentials are (*a*) Relief of pain by analgesics and by heat, (*b*) Improvement of muscle tone by exercises and occasionally by electrical treatment, and (c) Stretching of ligaments and joint capsule by traction, sling exercises and occasionally by manipulation.

Radiotherapy is of doubtful value in osteo-arthritis and should not be used as a routine method. Joint injection with anæsthetic solutions, lactic acid and hydrocortisone have been advocated. While undoubtedly these seem to give temporary relief in certain patients, this method of treatment is, on the whole, not convincing.

Osteo-arthritis of Special Joints

The Hip Joint. The onset of arthritis in this joint is accompanied by pain and limitation of movement with increasing flexion and adduction deformity At first this is corrected by compensatory lordosis and tilting of the pelvis. If both sides are affected, or in severe cases, the deformity may be such as to prevent walking and to confine the patient to his bed.

this, many attempts have been made to dispense with the plaster spica, reliance being placed upon internal fixation by various appliances.

Central dislocation of the hip a *method devised* by Charnley aims at stability by driving the shaped femoral neck into a hole bored in the floor of the acetabulum. Although bony union is not always obtained, and some movement may persist in the joint it is claimed that this is painless.

Arthroplasty The aim here is a mobile and painless joint. While perhaps 60 per cent. or more of normal movement may be obtained, slight discomfort is usually present and in some cases pain may be severe enough for another type of operation to be performed *Nevertheless*, *an arthroplasty* is specially useful in bilateral arthritis in the middle-aged or elderly The mobile joint enables the patient to sit in comfort, but for walking the use of a stick is almost always necessary These points should be put to the patient before operation Three types of arthroplasty are available

Excision of the joint. This is indicated in rheumatoid arthritis in which other types of arthroplasty are not successful A good range of movement is obtained but at the expense of stability

Cup arthroplasty is suitable where there is a good length of femoral neck.

In replacement arthroplasty the head and neck of the femur is replaced by a metal prosthesis.

Osteotomy McMurray's osteotomy consists of division of the femoral shaft at the level of the lower border of the acetabulum. The shaft is displaced inwards to form a buttress beneath the femoral head. It is essential that union should be obtained between the great trochanter and the shaft as in the treatment of ununited fractures of the femoral neck. Until union has occurred the osteotomy must be stabilized either in a plaster spica for three months or by internal fixation. The operation offers relief from pain a stable joint with a moderate range of flexion, but little abduction or rotation

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The Knee Joint. This is a common disease in the middle aged, and is often bilateral. Pain crepitus and swelling, due to synovial thickening or effusion are the main symptoms. The quadriceps muscles are wasted but movements are only slightly limited except in severe cases. Loose bodies may cause locking or occasionally synovial fringes may be nipped Treatment is essentially conservative and much relief may be obtained by muscle exercises, faradism and the wearing of an elastic knee-cap or crêpe pressure bandage Radiant heat or diathermy is comforting. The operation of arthrodesis is seldom indicated but loose bodies which are causing locking should be removed.

The Great Toe (*Hallux Rigidus*) This is a common site and may be the

result of injury or secondary to deformities of the foot It may be treated by excision of the base of the proximal phalanx (Keller s operation) or by arthrodesis.

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Rheumatoid Arthritis

This is typically a polyarthritis. The lesion is a subacute or chronic inflammation arising primarily in the synovial membrane but later involving other joint structures. Suppuration does not occur Various factors appear to influence the onset of the disease Of these must be mentioned the relation to stress and emotional disturbances which seem frequently to precede the onset of arthritis. The influence of a septic focus on the disease is questionable but there seems no doubt that joint disease, which closely resembles rheumatoid arthritis, can occur as a result of sepsis although the organisms in the focus may not be recoverable from the joint. Lastly the relationship between acute rheumatic fever and rheumatoid arthritis is doubtful, for most patients suffering from the latter have never had acute rheumatic fever

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general bone rarefaction throughout the body except as a result of prolonged rest in bed a change which is not peculiar to rheumatoid arthritis.

The muscles concerned with the affected joint become atrophied to a severe degree. When this occurs in the hand for instance the wasting may simulate that of a peripheral nerve lesion Anæmia is a marked feature of rheumatoid arthritis and the erythrocyte sedimentation rate is always raised.

Still's Disease This is a variation of rheumatoid arthritis occurring in children. The joint lesions, which are comparable to those found in adults, are accompanied by enlargement of the spleen and of the lymphatic nodes throughout the body

Arthritis and Psoriasis These two diseases are often associated. The joint changes are those of rheumatoid arthritis, but the terminal, instead of the proximal finger joints are affected



FIG. 18 13 RHEUMATOID ARTHRITIS.
The swelling of the proximal interphalangeal and metacarpophalangeal joints is well shown. Note hyperextension and ulnar deviation of fingers.

Intermittent Hydrarthrosis This is a rare prelude to rheumatoid arthritis in which a large effusion may appear in a joint without obvious cause. It is often painful and if the joint is subjected to a synovectomy the early histological changes of rheumatoid arthritis are found in the synovial membrane

Clinical Aspects. *There are two clinical types of the disease*

Subacute Arthritis. This tends to affect the small joints of the hands and feet in the young female patient. Usually the proximal joints of the fingers are involved (Fig. 18 13) The patients are thin, pale and anæmic. The extremities are cold and clammy and as already mentioned there is often a history of some emotional upset. The disease may spread to the wrists and other joints including the spine. In time, there is severe muscle wasting and ankylosis may develop together with gross deformity The fingers become hyperextended at the proximal interphalangeal joints and deviated towards the ulnar side of the hand. Tendon ruptures are frequent and these may account for some of the deformities. Rupture of the flexor tendons may

occur in association with distension of the ulnar bursa In some cases joint destruction is of the neuropathic type resulting in much bone absorption and instability (*arthritis mutilans*) This is especially seen in the fingers. On examination there is increased heat a boggy synovial swelling with little fluid, restricted movement and muscle spasm

Chronic Arthritis Arising in a middle-aged patient, this condition affects one of the larger joints. The differential diagnosis from tuberculosis may at first be difficult until other joints become affected

Radiology Since this is an inflammatory disease the early radiological change common to all inflammation of bone will be present, namely rarefaction Later actual bone destruction is apparent Typically there is little bone reaction and there are no osteophytes Ankylosis may eventually result (Fig.18 14)



FIG. 18 14 RHEUMATOID ARTHRITIS SHOWING BONY ANKYLOSIS OF BOTH HIPS. The rarefied texture of the bone is well seen.

Treatment. The disease is subject to remissions and apparent improvement may therefore not be connected with the treatment given at that particular time. Treatment is best carried out by a team comprising physician, orthopædic surgeon, and physical medicine specialist. The treatment of the systemic disease is a medical problem. Attention to general health, treatment of the anæmia, the use of drugs, *e.g* aspirin phenylbutazone and cortisone, must all be considered.

Splints are used to rest inflamed joints and to prevent deformity They must be removed periodically for joint movements to avoid stiffness. Heat is valuable in the later stages, to assist in restoration of movement and this may be applied to the hands in the form of wax baths.

The aim of physical treatment may be summed up as rest to the joints, combined with gentle movements several times daily For this reason treatment is better carried out in hospital rather than at home.

The Surgery of Rheumatoid Arthritis. *Arthrotomy* The opening and washing out of larger joints is useful when the disease is mainly synovial and there is an effusion containing fibrinous clots.

Synovectomy This operation is indicated in larger joints, particularly the knee The disease should be mainly synovial and without gross bone destruction or marked restriction of movement from adhesions if improvement is to be expected

Arthroplasty This may be indicated in the hip or elbow joints. A formal cup arthroplasty on the hip joint is seldom successful. The most useful type is an excision of the femoral head and neck in order to obtain painless movements.

Arthrodesis This is indicated for pain in the knee and sometimes in the wrist joint.

Ankylosing Spondylitis

This is the term applied to a condition of the spine which results in rigidity and kyphosis. It is seen most frequently in young adults, men rather than women The disease resembles rheumatoid arthritis in many respects, but opinions differ as to whether it should be regarded as a separate disease In both there may be a raised blood sedimentation rate and considerable anæmia. The spine is stiff and rigid (hence the name "poker back" sometimes applied to it), and this results from absorption of the intervertebral discs from synostosis of the vertebral bodies, sometimes with the formation and interlocking of osteophytes, and especially from ossification of the spinal ligaments. Pain is often a marked feature and is due to irritation of nerve-roots. A large portion of the spine is usually involved and a generalized kyphosis is the result. Two chief varieties have been described (*a*) von *Bechterew's* variety is one in which the upper cervical and thoracic regions are mainly involved, producing a limited kyphosis, with flattening of the chest and fixation of the ribs In many of these cases evidences are present of degenerative changes in the posterior columns of the cord and of irritation of the nerve roots and (*b*) the *Strümpell-Marie* type, sometimes known as *spondylose rhizomélique*, which is characterized by the affection first attacking the sacro-iliac joints and lumbar region, though it may also involve the hip and shoulder joints

In both forms there is a gradual extension of the process through the whole length of the spinal column and finally it attacks the articulations between the ribs and the vertebræ when these become fixed, the respiratory movements are considerably impaired, and death is likely to ensue from pulmonary disease. Acute attacks of iridocyclitis are a frequent complication of this condition.

Treatment Correction of anæmia and the elimination of septic foci are important. Pelvic sepsis has been stressed as important by some workers. The onset of deformity must be minimized by resting on a firm mattress at night and in some cases by spinal supports. Pain may be relieved in about one third of the cases by radiotherapy but it is now known that this treatment may carry the risk of damage to the bone marrow leading to leukæmia. When severe kyphosis is present, correction may be obtained in suitable cases by a spinal osteotomy Cortisone may benefit the condition.

Neuropathic Arthritis (Charcot's Disease)

This disease is a peculiar affection of joints met with in the course of locomotor ataxy It is slightly more common in women than men, and is almost always an early manifestation, occurring usually between the lightning-like pains and the onset of the ataxic symptoms. The most typical form is lighted up by some slight injury *e.g* a strain or sprain, and is characterized by a rapid painless distension of the joint with serum, which may also extend into the communicating bursæ there is some effusion into the surrounding

cellular tissue but without œdema. This distension may be so rapid that abnormal mobility or even dislocation may occur at the end of a few hours (Fig 18 5) The joints most frequently affected are the knee hip and shoulder occasionally more than one articulation or the spine is involved The course of the case varies in a few the fluid is gradually absorbed and the joint returns to its normal size and shape although somewhat weakened Sometimes the attacks of distension recur and after each the joint becomes more and more crippled. Two chief types of the affection are described (1) In the *atrophic* variety the more common, the bones become eroded to a considerable extent, the ligaments stretched and a weak, flail-like articulation remains in which the ends of the bones are atrophied and displaced (Fig. 18 16)



FIG 18 15 CHARCOT'S DISEASE OF THE RIGHT KNEE.
The joint is distended with fluid, and displacement of the tibia is commencing.

(2) In the *hypertrophic* form new bone forms here and there under the synovial membrane, especially where there is much distension, so that on compression of the swelling between the hands a sensation is produced similar to that imparted by grasping a bag of bones. After a time these bony masses become welded together a circumstance which subsequently leads to ankylosis of the joint (Fig. 18 17) The disease sometimes runs a more chronic course and then closely resembles osteo-arthritis, since there is little effusion, while the ends of the bones are eroded, and osteophytes, perhaps of great size, form around the edges of the cartilages, leading to defective mobility and crepitus It should be noted that the hypertrophic stage may follow the atrophic and that both are steps in an identical process

The same type of articular lesion occurs in *syringomyelia* a disease which consists in a gliomatous change in the spinal cord, usually in the cervico-dorsal region. It is characterized by loss of the senses of pain and of heat or cold, but tactile and muscular sensation persists. Atrophy of various muscles of the hand or forearm also occurs, while trophic lesions, *e g*

whitlow perforating ulcer etc. are common. Joint troubles are observed in at least one-third of the cases, mainly in the upper extremity tabes generally affects the lower Either atrophic or hypertrophic phenomena are developed, and the course is identical with that of Charcot's disease, except that suppuration is a little more likely to follow owing to the frequent presence of infected sores.

Somewhat similar in nature to Charcot's disease is the chronic arthritis met with in those conditions where the nervous supply to a limb is impaired as a result of central or peripheral disease of the nervous system. Thus, it may follow spina bifida, hemi- or para plegia of cerebral or spinal origin,



Fig 18 16. Charcot's Disease of the Hip Joint Atrophic Variety showing a Fracture of the Femoral Neck and multiple Loose Bodies.



Fig. 18 17 Charcot's Disease of the Knee Joint Hypertrophic Variety

or may be secondary to a peripheral neuritis, due to either injury syphilis, rheumatoid arthritis, diabetes or leprosy The terminal articulations of fingers or toes are those most often affected (acro-arthritis), although larger joints may be involved

Diagnosis The diagnosis of Charcot's disease from osteo-arthritis is, as a rule, readily made if one remembers the following points Charcot's disease is usually characterized by a rapid onset, limitation to one joint, considerable effusion, absence of articular pain, atrophy of the ends of the bones, and a tendency to the production of a weak, flail-like joint, while the early general signs of tabes are also observed especially the lightning pains and the Argyll Robertson pupil. Osteo-arthritis, on the other hand, comes on slowly often affects many joints, has but little effusion, is very painful, and is attended with marginal overgrowth or lipping of the cartilages. In the more chronic cases the distinguishing features are much less evident.

Treatment When the joint is distended with fluid it may be rested on a splint and supported by a firm bandage The effusion when considerable, may be removed by aspiration, but is very likely to re-collect. In the later stages, where the joint is entirely disorganized some form of fixed apparatus,

such as a moulded splint or caliper may be applied to render the limb more useful and it is remarkable how well a patient can get on in this way with a badly-affected joint. In severe cases an attempt may be made to carry out some form of arthrodesis. Successful results are reported Sometimes, especially in the ankle joint, it may be preferable to perform a below knee amputation.

Joints in Rheumatic Fever Acute rheumatism is a generalized disease affecting many structures. Chorea endocarditis and rheumatic nodules are more frequent manifestations of rheumatism than is synovitis. Swelling of a joint, however may be the first sign of acute rheumatism. It is unusual to find that a single joint is affected for more than a few days, indeed if it is, there should be suspicion that the diagnosis of rheumatism is incorrect The swellings tend to flit from joint to joint. The swelling is caused by an effusion and it is very rare for any permanent joint damage to remain Although rheumatic synovitis must be considered in the differential diagnosis of an acute arthritis, it is well to remember that rheumatism is very rare in children under two years. *When any doubt exists the joint should be aspirated* and the fluid examined for organisms. No reliance should be placed on the *therapeutic effect of salicylates as a diagnostic method.*

Gouty Arthritis. This is characterized by certain well marked features. It often attacks the metatarsophalangeal articulation of the great toe (podagra) or the metacarpophalangeal joint of the thumb (cheiragra) Its onset is usually sudden and it frequently commences in the middle of the night. The tissues around the joint become swollen, red, shiny and œdematous, while the superficial veins are prominent. The attack is exceedingly painful, and the skin exquisitely tender These symptoms pass off in the course of a few days, leaving the articulation swollen and sensitive.

Even a single attack results in a slight deposit of sodium biurate in acicular crystals in the matrix of the articular cartilage close to the surface but when the joint has been several times inflamed, the whole thickness of the cartilage may be invaded by this chalky deposit, while the ligaments and ends of the bones are also infiltrated. In the smaller joints it may increase to such an extent as to form well marked swellings, or " tophi," similar in character to those so commonly seen in the external ear the skin sometimes gives way over them, and a chalky discharge results. In some cases the cartilages are eroded and eburnation of the exposed bone may follow as in osteo-arthritis. The treatment of acute gout consists in fomenting the parts or applying glycerin and belladonna, while colchicum and cortisone are specific. Probenecid is useful in the treatment of chronic gout.

Hæmophilic Disease of Joints

In hæmophilia any injury to a joint may lead to a copious effusion of blood into the articular cavity which becomes suddenly swollen and distended The blood remains fluid for a time, but at length coagulates and the joint then becomes tense and firm, and is often hot and tender Total recovery may ensue, but if the condition recurs, as is so frequently the case, the effects on the articular surfaces are curious the cartilages usually retain their normal colour but become thin, worn and rough, especially at the points of greatest pressure fibrillary degeneration of the matrix may occur and in some cases the cartilage has been found totally absent, being replaced by fibrous tissue. Ecchondroses subsequently developing into bone are formed

at the margins of the joint surfaces, the changes thus produced being somewhat akin to those of osteo-arthritis. The ligaments and synovial membranes are slightly thickened, and usually of a russet brown colour Adhesions are often present, causing considerable impairment of mobility

Treatment This consists in keeping the part at rest, and applying ice in the early stages while, later on, the joint may be treated as for osteo-arthritis Aspiration must not be attempted.

Loose Bodies in Joints

Several varieties of loose body are met with in joints, which may be described as follows

Melon-seed Bodies These consist of fibrin derived from altered blood-clot, or more frequently from a fibrinous exudation in cases of very chronic tuberculous disease At first irregular in shape and laminated in texture, they are generally transformed into round or flattened pellets or elongated masses by the movements of the articulation. Bursæ and tendon sheaths are much more frequently affected than joints (*e g* in subdeltoid bursitis and compound palmar ganglion) The number present is usually considerable,

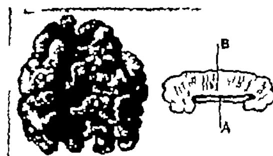


FIG 18 18. LOOSE BODY FROM JOINT PROBABLY THE RESULT OF OSTEOCHONDRITIS DISSECANS. (*Royal College of Surgeons Museum*)
A Bone. B. Cartilage.

while there is also some glairy effusion causing distension and a certain amount of creaking.

Osteochondritis Dissecans This condition is more fully described elsewhere in this chapter Portions of articular cartilage may be separated from certain joint surfaces such as the medial condyle of the femur the capitellum of the humerus, the superior articular surface of the talus, or the superior aspect of the head of the femur probably as a result of trauma, the condition being known as osteochondritis dissecans. Usually in addition to the actual cartilage a flake of bone is found to be separated as well. The separation may be complete or the fragment may remain suspended from the main articular surface. Occasionally the fragment appears to have been displaced and then become reattached to its old bed. If it has lain free in the joint for any length of time, the cartilaginous surface will grow around the bone so that the latter serves to form a central nucleus. Radiography may demonstrate the loose body and the cavity in the lower end of the femur from which it has been derived.

Osteochondromatosis Loose bodies sometimes develop from cartilaginous nodules in the synovial fringes or villi, which either become pedunculated then occasionally wearing a bed for themselves in the articular

surface, or may be totally detached Such structures are usually lobulated and irregular in shape, and consist of calcified cartilage or bone while a certain amount of normal cartilage is also present.

Ecchondroses These may be broken off in cases of osteo-arthritis, or even portions of the articular cartilage showing villous changes A non articulating epiphysis such as the internal epicondyle of the humerus may become broken off and displaced into the joint, but remains *attached to the* muscle origin Although cut off from all vascular supply the growth of the cartilaginous portion of these loose bodies is said to continue, owing to the fluid *which bathes their surfaces.*

Symptoms. These are caused by the loose body being caught between the articular surfaces, leading to a temporary locking of the joint, with severe pain The fixation is momentary since the loose body is readily displaced but an attack of synovitis follows. When this has happened several times, the ligaments are likely to become relaxed and the joint loose and distended It may then be possible to feel the loose body and to shift its position, but frequently it slips away into the interior of the joint owing to its ready *mobility From this point of view the term Gelenkmaus (joint mouse)* as applied to this affection, is most happy The knee and elbow joints are those frequently affected

Diagnosis. The diagnosis between a loose body and a torn meniscus in the knee joint is not always easy since in both conditions painful locking of the joint occurs. The fixation, however is momentary in the case of a loose body but may persist until reduced in the latter while a localized tenderness may be detected corresponding to the site of the injury to the *meniscus. Moreover the history of the case is very different, since the dis*location of a meniscus is always primarily referred to some twist or sprain of the joint, whereas with a loose body no such trauma need be present. It is always possible to detect a loose body by radiography if there is any bone in it. The treatment consists in the removal of the loose body by an open operation.

General Affections of the Skeleton

A considerable number of diseases affect the skeletal system as a whole though one particular portion may be involved by one particular disease

The following classification has been modified from Fairbank s *Atlas of General Affections of the Skeleton* (E. & S Livingstone, 1951), to which due acknowledgment is made.

(1) *Congenital* Osteogenesis imperfecta, achondroplasia, diaphyseal aclasis, myositis ossificans progressiva.

(2) *Acquired, of Unknown Origin* Paget s disease, senile osteoporosis.

(3) *Metabolic.* Rickets, scurvy osteomalacia.

(4) *Endocrine* Acromegaly Fröhlich s syndrome, hyperparathyroidism, fibrous dysplasia of bone

(5) *Toxic or Infective* Congenital syphilis, hypertrophic osteoarthropathy infantile cortical hyperostosis.

(6) *Errors in the Hæmopoietic and Lymphatic Systems* Leukæmia, Hodgkin s disease.

(7) *Multiple Neoplasms* Metastatic carcinoma, myelomatosis, lymphosarcoma, neuroblastoma.

Some of the above conditions are described elsewhere in the orthopædic

section and the chapter on the endocrine system. The remainder will now be considered.

Congenital Errors of Development

Osteogenesis Imperfecta (*Fragilitas Ossium*) Another name for this disease is idiopathic psathyrosis It is a condition in which the bones are fragile and fracture readily Deformities may result from malunion of fractures or from bending of the softened bones. When severe deformities are present at birth, the case may be mistaken for one of achondroplasia. The cause is unknown but there is a hereditary tendency and females are affected more often than males. The eyes in many cases have sclerotics of a deep indigo blue colour Fractures occur from slight trauma, such as may be readily sustained by any child, and the number of these and time of onset of the first may vary The severe cases do not survive but there is a tendency for the fractures to get less in number as the child grows. The children are dwarfed and severe scoliosis may be present. The skull may be broad.

The pathological changes are those of imperfect formation of bone trabeculæ The blood chemistry is normal. In a skiagram the bones may be short and thick, or long and slender with a thin cortex and rarefied appearance. Deformities due to multiple fractures or bending may be seen. The fractures heal readily sometimes with excessive callus formation.

Achondroplasia (*Chondrodystrophia Fœtalis*). This is a congenital condition, obvious at birth, which is the commonest form of dwarfism. Many are stillborn. The occurrence of most cases is sporadic although there is a hereditary tendency in some families. The appearance of the patient is characteristic, with large head, long body and short limbs. The head is large because the skull is broad suggesting hydrocephalus, the nasal bridge depressed and the face small. The limbs are short in relation to the length of the trunk. The hands are broad with stubby fingers which diverge, an appearance described as trident hand" The buttocks are prominent so that the patient seems to have marked lordosis. The mental development is normal.

The pathological feature is a defective ossification of cartilage at the ends of the long bones with disorderly growth of cartilage cells. Radiology shows short sturdy bones. The epiphyses are placed close to the diaphysis so that the joint space appears to be wider than normal. Marked bending of the long bones is unusual. Changes are seen in almost all parts of the skeleton except the facial bones.

Diaphyseal Aclasis (*Multiple Exostoses*). This is a familial condition in which the limb bones are short, thickened at the ends and are the site of multiple bony outgrowths. The name diaphyseal aclasis was coined by Keith to indicate a lack of modelling power in the periosteum, which accounts for the deformities. Each exostosis consists of cancellous bone covered with a layer of cartilage cells and surmounted by a bursa. The cartilage cells are derived from the epiphyseal cartilage and behave in the same way Growth of the exostoses will therefore cease when bone growth is finished. The outgrowths arise near the epiphyseal line but as the bone elongates, may be found later at a distance from it. In structure the outgrowth is sometimes pedunculated though often sessile. [illegible] edicle tends to slope towards the epiphyses but to be abrupt and h[illegible] ards the diaphysis (Fig. 18 32).

The only symptoms are thos[illegible] by the size or position of the

outgrowth for instance when arising on the medial side of the knee, horse riding may be difficult Occasionally tendons may catch on the outgrowth when the joint is moved This may produce a type of "locking" or a snapping joint. Treatment should be confined to the removal of any exostosis which is causing symptoms.

Myositis Ossificans Progressiva. This condition is described on p 172.

Acquired Conditions of Unknown Origin

Paget's Disease (*Osteitis Deformans*) This is a common skeletal disease, first described by Sir James Paget in 1877 The onset is insidious, occurs late in life and progresses very slowly The characteristic clinical features



FIG. 18 19 OSTEITIS DEFORMANS IN LATE STAGE.
Note size of the skull and curvature of humerus and of bones of forearms.

are best seen in the long bones and consist of thickening and bending, usually in the antero-posterior plane

The usual sites for the disease are the pelvis, lumbar vertebræ, vault of skull and long bones, particularly the tibia and femur The pathological change consists of decalcification, with patches of increased density and fibrosis of the marrow space. Increased vascularity may be marked. The blood chemistry is not characteristic, but shows a greatly increased alkaline phosphatase level with increased excretion of calcium and phosphorus. The serum calcium is normal.

Clinical Features The disease is often discovered accidentally during the course of radiographic examinations for other conditions. Symptoms may therefore be absent, but the patient may seek advice because of bowing of a bone or because of pain. Headache may be present when the skull is affected and there is sometimes deafness from otosclerosis. Enlargement of the skull may first be noticed because of an increase in the size of hats. There may be aching in the limb but pain is usually not severe. The spine may

become kyphotic and the limbs bent, so that in advanced cases there is marked diminution in stature. On examination of a superficial bone such as the tibia, the shaft is broadened and bent, the anterior edge rounded and the bone may feel warm due to increased vascularity

The diagnosis is usually simple when a long bone is affected. The bending of the tibia in rickets occurs near the extremities, and the bone is slender and the margin sharp in contrast to the rounded and thickened bone of Paget's disease When a lumbar vertebra is involved, the radiological appearance may be confused with an osteosclerotic deposit from carcinoma of the prostrate. Clinical examination, together with an estimation of the

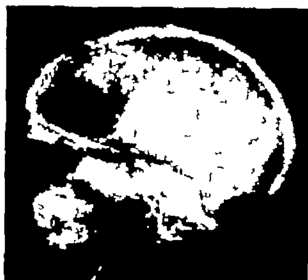


FIG 18 20. PAGET'S DISEASE OF THE SKULL.



FIG. 18 21 PAGET'S DISEASE OF THE TIBIA.

serum acid phosphatase level, which is raised in prostatic carcinoma, will help to differentiate the two conditions.

Radiological Appearances These are characteristic and show that the disease starts in the cortex of the bone which becomes thickened and encroaches upon the medullary cavity until it is obliterated. Patches of rarefaction and of increased density may be seen and the bone is sometimes markedly striated.

The progress of the disease is usually slow and uncomplicated, the patient eventually dying of some cause other than Paget's disease. Two complications, however may occur (*a*) *Fractures* These are fairly common and occur in the upper third of the femoral shaft or the upper third of the tibia. The fracture line tends to be transverse, clean cut and without comminution. Healing occurs as in ordinary fractures. (*b*) *Sarcoma* The incidence of malignant change has been stated to be as low as 2 per cent. and as high as 11 per cent. The lower figure is probably the more accurate. Bone sarcoma in the elderly is rare, the average age of patients with this disease being about twenty five years.

Treatment The treatment of Paget's disease is purely symptomatic, no remedy at present known having any control over the disease. Sarcoma must be treated by amputation or irradiation.

Senile Osteoporosis (*Post Menopausal Osteoporosis*) This is a type of osteoporosis affecting mainly the cancellous bones of the hands feet and vertebral bodies It is most common in women after the menopause, but is sometimes seen in men The cause is thought to lie in the lack of stimulus to osteoblastic activity brought about by involution of the ductless glands. Although the radiological evidence of osteoporosis is marked the blood chemistry is normal.

Clinical Features The spinal symptoms are those of backache and an increasing kyphosis of the round back type Slight trauma may cause pathological wedge-fractures and when these occur severe pain is experienced. Skiagrams show considerable osteoporosis and the intervertebral discs are often biconvex. The intrusion of the swollen discs into the vertebral bodies gives rise to the appearance of biconcave " fish tail " vertebræ.

The differential diagnosis between vertebral collapse due to senile osteoporosis and that due to malignant disease may be difficult. Factors to consider are the presence of a primary tumour the blood picture, E.S.R., marrow smear and blood chemistry In addition the radiological appearances of other bones must be investigated

Treatment There is no specific treatment. Recalcification of bone cannot be achieved by hormone or calcium therapy Some general benefit, however may be derived from hormone treatment, especially testosterone, and ultra violet light is useful. Relief of backache can be obtained by the wearing of a spinal support but the severe pain of a recent wedge fracture can only be treated by bed rest together with analgesics.

Metabolic Diseases

Rickets. This is a deficiency disease in which growing bones are affected The changes occur therefore chiefly in the region of the epiphyses, where an excess of osteoid material is laid down, but is incompletely calcified This may be expressed by saying that there is an increased preparation for bone formation which is not completed The normal arrangement of the



FIG 18 22. A CHILD WITH WELL-DEVELOPED RICKETS.
The enlargement of the epiphyses of the radius and tibia is well seen.

cartilage cells is lost and proliferation occurs *in an irregular fashion*. The bones are soft and can be cut easily

There are many forms of rickets of which the chief are

Infantile Rickets This is the commonest type even in countries with a high standard of living and medical services, where rickets has become an uncommon condition The disease is due to two factors (*a*) Deficiency of vitamin D in the diet (*b*) Lack of exposure to sunlight, by means of which vitamin D is synthesized from ergosterol.

The disease usually appears in the first year of life. The early symptoms may be restlessness, swelling about the head and late dentition. The



FIG. 18 23 INFANTILE RICKETS.
The epiphyseal lines are wide and the metaphyses are "cupped."



FIG 18 24 RICKETS SHOWING BROADENING OF THE EPIPHYSEAL CARTILAGE AND EARLY BUTTRESSING OF THE CORTEX IN THE CONCAVITY OF THE BOWING

abdomen is protuberant and the child is late in standing and walking. Generalized hypotonia of muscles may be observed These changes suggest that the metabolic disturbance affects tissues other than bone and cartilage. However the chief changes are always osseus. The deformities occur as a result of stress on softened bones brought about by a variety of factors which include posture, weight bearing, muscle pull and respiratory movements. In the long bones the deformity is produced by an increase in the natural curvature.

The epiphyseal cartilages become enlarged and these may be felt at the wrists or seen as "beading" of the costochondral junctions (the "rickety rosary") The head is large with prominent forehead due to frontal bossing (Parrot's nodes) and there is delay in closure of the fontanelles. The teeth

erupt late and are deficient in enamel The spine is kyphotic and the chest flattened scoliosis may occur in children who can walk In some cases the sternum may protrude forwards constituting the "pigeon breast appearance

Deformities in the lower limbs are characteristic Knock knees or bow legs may be present The bowing of the tibiæ is antero-lateral and most marked at the lower ends. This may be due to the child sitting in the crossed legged or "tailor position The arm bones may be bent because the child supports his weight on his hands when sitting Greenstick fractures may occur The pelvis is flattened or triradiate In severe cases the appearance of the child is characteristic and the retarded growth produces considerable dwarfing. In many cases, however the deformities are comparatively slight and the presence of rickets must be looked for both by clinical and radiological examination. The alkaline phosphatase is raised

The typical radiological appearance is that of a wide epiphyseal line with enlargement of the end of the diaphyses which are "cupped" (Fig 18 23) There is general hypocalcification of bone As healing progresses, the bones become recalcified In the long bones, if bending has occurred, buttresses of new bone may be seen filling the concave side of the shaft (Fig. 18 24)

The essential feature of treatment is the correction of the diet, with the addition of cod-liver oil Exposure to sunlight or ultra violet light is valuable. The prevention of deformities is important. No weight bearing is allowed until the disease is healed and the cross-leg position should be avoided when the child sits. A restrainer may be necessary in young children to keep them lying. Splints to prevent walking must project beyond the feet and suitable cross bars can be added so that the leg is kept in the neutral position and does not roll out. Residual deformities may need correction by osteotomy

Resistant Rickets A small number of cases show no improvement under treatment or relapse when this is discontinued Very large doses of vitamin D may be necessary in order to secure healing and a few patients seem to require treatment to be continued throughout their life These patients show the usual deformities of rickets and complain of excessive fatigue after moderate exercise. They tend to be short in build or are dwarfed

Rickets occurring in adolescents may be of this type or the disease may be acquired at this age

Cœliac Rickets In this disease there is a deficient absorption of fat and vitamin D from the alimentary tract.

Renal Rickets This type, also called renal osteodystrophy is associated with renal disease, either congenital or acquired (Fig. 18 26). The parathyroid glands may be enlarged and it is thought that both these and the bone changes are the result of the renal disease The origin of the renal abnormality may be an obstruction resulting in back pressure effects, or due to an inherent defect in the kidney If the latter the metabolism of calcium and phosphorus is abnormal In addition amino-acids and sugar may be excreted to excess.

Dwarfism may be an early feature, together with deformities (*e.g* knock knee) but bending of the long bones is usually not a feature. Sexual development may be delayed, and polyuria or abnormal thirst may be present. Most cases die of renal failure at an early age. The radiological changes are atypical. There is no bending of long bones, but some osteoporosis may be

seen The epiphyseal line is widened but "cupping" of the metaphysis is absent (Fig. 18 25)

Scurvy This is a metabolic disease due to a deficiency of vitamin C. It may be seen in both an infantile and adult form

Infantile Scurvy Cheadle in 1878 drew attention to the distinction between infantile scurvy and rickets which up till that time were frequently confused, and Barlow in 1883 published an accurate description of the disease Hence the name Barlow's disease which is sometimes given to it. Scurvy is seen most often between six and twelve months of age.



FIG 18 25 RENAL RICKETS. Changes are seen in the radial, ulnar and metacarpal metaphyses.

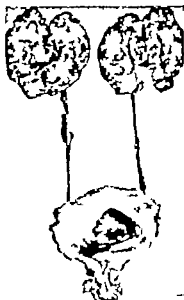


FIG 18 26. CONGENITAL CYSTIC DISEASE OF THE KIDNEYS IN A CHILD SUFFERING FROM RENAL RICKETS

The clinical features are those of a sudden onset with fever sometimes preceded by a period of malaise The presence of subperiosteal hæmorrhages is characteristic and these are accompanied by pain, swelling and tenderness. Loss of use of the limbs because of pain gives rise to the appearance of pseudo-paralysis. The epiphyses are affected and may separate from the shaft but the joints escape. The gums appear spongy swollen and purple, and bleeding from them is common. Occasionally there may be petechial hæmorrhages in the skin, blood in the stools, or blood cells in the urine but obvious hæmaturia is unusual.

The radiological appearance is like that of congenital syphilis, but this disease tends to appear in the first six months of life, scurvy in the second six months. The earliest sign is the appearance of a clear area near the end of the shaft and this is separated from the epiphysis by a dense band of bone. At about ten days from the onset of the disease the subperiosteal hæmorrhages will begin to ossify The tender limbs of scurvy have been mistaken for osteomyelitis and the pseudo-paralysis for poliomyelitis.

Treatment consists in the administration of vitamin C in the form of fruit juice or tablets of ascorbic acid The prognosis is good and the symptoms disappear in a few days

Adult Scurvy This is a disease of historic interest in connection with the long sea voyages of bygone days The disease is occasionally seen among the elderly population in poorer districts whose diet may consist largely of bread and margarine and tea The clinical manifestations are usually pain, lethargy and depression. Subcutaneous bruises and anæmia are common findings, but bleeding from the gums is rare

Osteomalacia (*Mollities Ossium*) This is a disease of adults corresponding to rickets in childhood and is due to similar causes, namely errors

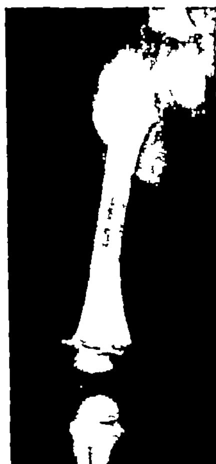


FIG. 18 27 INFANTILE SCURVY
The film shows a clear area separating the shaft from the epiphysis. There is early ossification of the subperiosteal hæmorrhages.

of diet, lack of vitamin D or calcium and lack of sunlight. It is common in Eastern countries and affects females more often than males. It may be seen after starvation brought about by conditions of war or famine (starvation osteopathy) The disease is aggravated by pregnancy Tetany may occur and spontaneous fractures are common. The chief pathological change is a reduction of ossified bone and an increase in osteoid material.

The clinical features are *pain in the back or thighs, abnormal gait, curved bones* and kyphosis. Normal childbirth may be impossible because of the deformed pelvis and Cæsarian section is then necessary Skiagrams show generalized hypo-calcification and bending of the long bones, triradiate pelvis and bi-concave vertebral bodies.

Endocrine Disorders

Acromegaly This is a rare condition first described by Pierre Marie in 1886. The changes mainly involve the bones but soft structures are also affected The characteristic features are seen in the face which becomes heavy in appearance with enlarged lower jaw prominent brows, everted lips and thickened skin The hands and feet are enlarged and spade-like. The



FIG. 18 28. A MAN AGED 28 WITH WELL-MARKED ACROMEGALY
Note the great enlargement of the lower jaw and the left external squint.

spine may be kyphotic or scoliotic and the chest increased in depth. The onset of the disease is insidious and usually begins in the third decade of life but when it commences in childhood or adolescence, gigantism will result. Many giants become acromegalic.

The cause of the disease is hyperpituitarism due to an eosinophilic adenoma of the anterior lobe of the gland. The sella turcica is enlarged. The changes in the bones are those of overgrowth in length or thickness according to the age of onset of the disease. Osteoarthritis is common.

Symptoms In addition to the changed appearance, the patient may complain of headache, lassitude and fatigue Excessive thirst and polyuria may indicate the presence of diabetes mellitus which is said to occur in about 50 per cent. In the later stages of the disease cranial nerve palsies may appear Progress, however is often slow and the patient may live for many years.

Treatment is symptomatic. Destruction of the pituitary lesion by means of radiotherapy may sometimes be attempted but the results are not encouraging.

Hyperparathyroidism (*Generalized Osteitis Fibrosa*). Also known as von Recklinghausen s disease of bone, this is a rare condition in which a tumour of one of the parathyroid glands is responsible for an upset of calcium metabolism. There is a raised level of serum calcium with a low serum phos-

phorus Excretion of urinary calcium and phosphorus is increased and there is thus a negative calcium balance The disease affects middle aged women rather than men. The skeleton is affected by generalized osteoporosis and the soft bones may bend Cysts may be present in them Bilateral renal calculi are often found and should arouse suspicion of the disease. The patient may complain of vague pains or aching in the limbs or back. Defor mities may result from bending or fracture of the bones and there may be gastro-intestinal symptoms such as a duodenal ulcer particularly resistant to treatment. Removal of the affected parathyroid gland causes a rapid alleviation of symptoms and a return to normal blood chemistry, tetany in the post-operative period is usual.

Fibrous Dysplasia of Bone It is important to realize that another form of osteitis fibrosa exists which is more common in children and to which attention was drawn by Albright It is not associated with abnormal blood chemistry nor with parathyroid tumours Monostotic or polyostotic fibrous dysplasia affects one or several bones but the changes are not generalized throughout the skeleton as they are in hyperparathyroidism. There may be pigmentation of the skin and in females the bone changes are associated with the precocious onset of puberty

Toxic or Infective Diseases

Hypertrophic Osteo-arthropathy This condition was also first described by Pierre Marie in 1890 The syndrome is that of clubbing of the fingers, periosteal thickening of the long bones, including the metacarpals and metatarsals, and polyarthritis (Fig. 18 29) In some cases these changes are



FIG. 18.29 CLUBBED FINGERS DUE TO CHRONIC EMPYEMA.

associated with cardiac or pulmonary disease, which may be infective (*e g* bronchiectasis) or neoplastic. In other cases no cause can be found. It seems therefore that the changes in bones and joints may be due to toxic absorption. A kyphosis or lordosis may be present.

In considering the diagnosis, a distinction must be made from other forms of polyarthritis or periostitis. There is no specific treatment, but when the cause can be found and removed the joint changes may clear up quite rapidly This has been observed for instance after removal of a carcinoma of the lung by pneumonectomy or even after denervation of the lung root.

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Tumours of Bone

Primary tumours arise in bone structures of mesodermal origin secondary tumours spread to the bone by the blood stream or by direct infiltration.

The diagnosis of a bone tumour depends upon clinical, radiological and histological examinations The correct answer will be found only by correlation of these findings In many cases classification may present considerable difficulties because the clinical behaviour of the tumour is not in accord with what would be expected from the histology For this reason a classification based purely upon histology is unsatisfactory and a better way is to use a simple classification related to the type of tissue in which the tumour arises. New knowledge may require alteration of the classification from time to time but the tendency is rather to simplify than to elaborate.

The following table is constructed on this basis and serves to cover the several varieties of primary bone tumours With the exception of the cancellous osteoma, primary tumours are comparatively rare. Secondary or metastatic tumours are far commoner but, in addition to these, neoplastic tissue may be found in the bones in the reticuloses such as Hodgkin's disease, leukæmia and in errors of lipid metabolism (e g eosinophilic granuloma).

Site	*Benign*	*Malignant*
Cartilage-forming tissue	Ecchondroma Enchondroma Osteocartilaginous exostosis*	Chondrosarcoma
Bone-forming tissue	Osteoma (Compact) Osteoma (Cancellous)	Osteogenic sarcoma
Connective tissue	Fibroma of periosteum Osteoclastoma	Fibrosarcoma Malignant osteoclastoma
Bone marrow		Reticulum-cell sarcoma Multiple myeloma
Vascular tissue	Hæmangioma	
Notochord		Chordoma
Enamel organ of teeth		Adamantinoma

* These are probably the same tumour

Chondroma. This is a cartilaginous tumour which tends to calcify or when large, to become malignant.

Enchondroma. This is found typically in the small bones of the hand. Being endosteal, it causes expansion of the bone with thinning of the cortex, and forms a spindle shaped swelling which is rarely more than 3 cm. in diameter Pathological fracture is common and, in fact, this is the usual way for the tumour to be discovered. The skiagram shows a cystic area of bone with a thin cortical layer and sometimes a few spots of calcification (Fig. 18 30) The contents should be curetted and the cavity swabbed with 90 per cent. alcohol to destroy any remaining cells. It is then filled with cancellous bone chips and the digit immobilized until the wound has healed.

Ecchondroma Multiple tumours of this type are occasionally seen in the hand and may attain the size of a large cherry More common is a single tumour attached to the end of a long bone or to a flat bone such as the pelvis, scapula or rib The tumour may grow to an enormous size some specimens being as large as a football. Radiology will reveal much calcification within the tumour and there is a tendency to malignant change The tumour will then become a *chondrosarcoma* (Fig. 18 31)

Chondrosarcoma This is a tumour of a relatively low degree of malignancy It may arise in a previously benign chondroma or appear spontaneously in some part of the skeleton An infiltrating type of chondro-



FIG. 18 30. CHONDROMATA. An enchondroma is seen in the fourth digit and ecchondromata are present in the fourth and fifth metatarsals.



FIG. 18 31 A LARGE CHONDROMA OF THE FEMUR WHICH HAS BECOME MALIGNANT

sarcoma is occasionally seen. In this variety the tumour may be present for some time as an apparently innocent enchondroma. It may suddenly take on malignant changes and infiltrate rapidly through the bone. The neck of the femur is a likely site for this to occur When metastases occur they are found in the lungs as in other types of sarcomata.

Large ecchondromata should be removed before malignant changes occur In the case of an enchondroma of the femoral neck, removal may not be justified unless malignancy is suspected, in which case the choice may lie between a local resection or disarticulation at the hip joint. In chondrosarcoma of the pelvic bones a hindquarter amputation may be feasible.

Osteoma. There are two types of osteoma compact or ivory and cancellous.

Ivory Osteoma. This is found in the skull, usually on the vertex, or in

connection with the orbit or external auditory meatus The tumour is solid and ivory like in consistence. When occurring in the orbit, the eye may be destroyed by mechanical pressure

Cancellous Osteoma This is a common benign tumour and is probably identical with the osteocartilaginous exostosis. When single it arises from epiphyseal cartilage near the end of a long bone. The tumour consists of a pedicle bearing a cauliflower like excrescence consisting of a thin cortical layer containing a mass of cancellous bone. A cap of cartilage surmounts the tumour (Fig. 18 32) Growth will cease when the epiphysis closes. The multiple variety is described under diaphyseal aclasis.



FIG. 18 32. OSTEOMA, CANCELLOUS TYPE, AFFECTING THE HUMERUS.
Note the gradual slope towards the epiphysis and the abrupt hook towards the diaphysis.

These tumours have little or no tendency to malignant change.

Osteoid Osteoma. This condition is included here since although it is possibly not a true tumour it has come to be regarded as a clinical entity The history is that of pain in a bone, worse at night, and of several months duration. If the bone is superficial a swelling may be felt. Radiology reveals a dense sclerotic area of bone surrounding a small clear area (Fig. 18 33) The appearance is somewhat like that of ch[illegible] ...ib or a Brodie s abscess. The condition may be found in th[illegible] ... or in other situations in the skeleton [illegible] vertebræ. On[illegible] clear area is found to consist of osteo[illegible] ...ls red or pin[illegible] (Fig. 18 34). There is no tendency to [illegible] ...ge and l[illegible] to a cure of the pain.



FIG. 18 33 OSTEOID OSTEOMA OF THE FIBULA.



FIG. 18 34 OSTEOID OSTEOMA.
Section of fibula showing vascular area.



FIG. 18 35 A LARGE OSTEOGENIC SARCOMA OF THE HUMERUS.
The tumour pulsated.

Osteogenic Sarcoma This is the most malignant type of bone sarcoma. The term osteogenic implies that the tumour arises from bone-forming tissue, but new bone may or may not be found in the tumour. The terms endosteal or periosteal indicate the main site of the growth, but owing to infiltration it may frequently occupy both situations. The cell type is characteristically that of a spindle cell but round cells and giant cells may be found. Differentiation into myxomatous, cartilaginous or bone tissue may occur and often there is a mixture of these in different parts of the specimen. The tumour spreads by local erosion and infiltration into the surrounding soft parts, but rarely ulcerates through the skin unless an enormous size is reached.



FIG. 18 36 OSTEOGENIC SARCOMA OF THE TIBIA.
A. Osteosclerotic type. B. Osteolytic type.

Usually before this can occur metastases arise in the lungs. Pathological fractures are common. The degree of vascularity of the tumour varies greatly. In some, increased heat may be felt and pulsation seen. The vascularity may be readily visualized by means of arteriography and this forms one of the aids to diagnosis.

Osteogenic sarcoma is a disease of adolescents and young adults up to the age of twenty five years. The exception to this occurs as a complication of Paget's disease in elderly patients. The common site is the lower limb in the region of the knee but the ends of any long bone may be affected. The tumour arises in the metaphyseal region of the bone rather than the shaft. There is often a history of preceding injury.

Symptoms These are pain and swelling. At first the pain is slight but after a month or so it becomes more severe and may keep the patient awake, and may eventually become intolerable. The swelling is diffuse and the bone may be tender. Involvement of muscle by the growth will cause limitation of movement in the neighbouring joint.

Radiology The appearances vary considerably. There are two main

types, the osteosclerotic and the osteolytic (Fig. 18 36) The osteosclerotic type may be mistaken for chronic osteomyelitis. Erosion of bone, together with a soft tissue shadow is suggestive of a tumour The classical sun-ray spindles of bone, radiating at right angles to the shaft are not always present (Fig. 18 37) They are not typical of osteogenic sarcoma and are sometimes seen with other tumours Often the new bone formation is irregular In osteolytic growths, the question of a *metastatic carcinomatous deposit* rather than sarcoma must be considered

The clinical and radiological findings must be considered together In every case a biopsy is justified and should be performed so that the his-

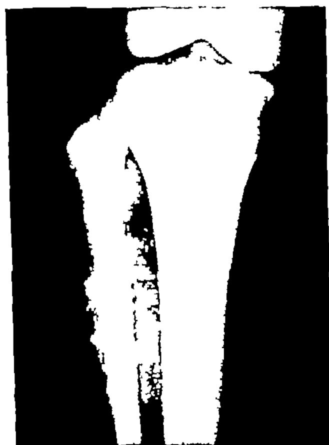


Fig. 18 37 Osteogenic Sarcoma of the Fibula. Note striæ of ossification placed radially to the shaft.

tological evidence may be added. It is only by weighing the evidence of these three investigations that a true diagnosis will be achieved The prognosis is extremely poor Very few patients survive for five years and the usual termination is death from lung deposits within a year to eighteen months.

Treatment Metastases occur early The mutilating operations of disarticulation at the hip or shoulder are seldom justified by the results obtained and make little difference to the prognosis. A combination of radiotherapy together with amputation at a level clear of the growth is probably the best form of treatment. Much will depend upon the radiosensitivity of the

tumour but undoubtedly there are unknown factors which decide the outcome probably before treatment has been started.

Fibroma. This tumour may arise from the fibrous layer of the periosteum or occasionally as an endosteal growth. Both forms are uncommon.

Fibrosarcoma. This tumour may arise from the periosteum or as a parosteal tumour in neighbouring fibrous tissue. The bone is then involved by direct spread.

The degree of malignancy is comparable to that of fibrosarcoma of soft tissue and may be considerably less than that of osteogenic sarcoma. The radiosensitivity is low and amputation offers a reasonable chance of cure.

Osteoclastoma (*Giant-cell Tumour*) This tumour is benign in the sense that it does not usually metastasize, but it causes local destruction of bone



FIG 18 38 OSTEOCLASTOMA OF THE LOWER END OF THE RADIUS. The trabeculation is well shown.

and may involve the neighbouring joint and soft tissues. Occasionally an osteoclastoma takes on the characteristic clinical and radiological features of malignancy although the histology may suggest that it is a benign tumour. The explanation may be that malignant changes are to be found only in certain parts of the tumour and that the biopsy material did not include one of these. A malignant osteoclastoma behaves like a sarcoma.

The tumour is found in persons between twenty and forty years of age. The typical site is at the growing end of a long bone, notably the lower end of the femur and lower end of radius (Fig. 18 38)

Pathology The tumour is endosteal, starting in the region of the metaphysis but soon invades the site of the epiphysis and abuts upon the articular cartilage. As it enlarges, expansion of the bone results from a process of

cortical absorption internally with new bone formation externally Nevertheless the cortex becomes so thin that a crepitant sensation is felt when it is pressed with the finger (egg-shell crackling) There is little tendency to spread along the medulla Pathological fracture is common and the fracture may extend into the joint, which is destroyed

The histological picture is that of masses of multinucleated giant-cells embedded in a groundwork of round or spindle-cells (Fig. 18 39).

Clinical Features These are pain and swelling, complicated later by the presence of a fracture. On radiological examination there is a well-defined transluscent area of bone which is trabeculated due to varying thickness of



FIG. 18 39 PHOTOMICROGRAPH OF AN OSTEOCLASTOMA. Note the giant cells.

bone. There is an absence of calcification typical of a chondroma. A similar radiological appearance may be due to a solitary bone cyst, but the situation is in the shaft and not at the end of the bone.

Treatment The tumour is relatively insensitive to radiotherapy but nevertheless will respond to suitable dosage Good results are reported

The ideal treatment is surgical resection but this is rarely possible unless the nearby joint is sacrificed. After resection the defect must be filled with a bone graft and ankylosis of the joint must usually be undertaken. Small tumours may be curetted and the cavity filled with cancellous bone chips, but recurrence is likely unless all the tumour has been removed A combination of curettage and radiotherapy is more likely to succeed.

Reticulum-cell Sarcoma. This type of sarcoma typically affects the shaft of the long bones and was originally described in children. It is seen however in young adults and may affect other bones, particularly the vertebræ and flat bones. This represents one type of Ewing s tumour

Pathology The tumour consists of masses of round cells with little or no intercellular matrix. Giant cells are not present. In some cases Ewing s sarcoma has been confused with secondary bone deposits from an adrenal neuroblastoma.

Clinical Features A swelling appears, which varies in size and may be accompanied by fever malaise and leucocytosis. There may be redness of the overlying skin. At first it may be mistaken for osteomyelitis and if incised in the belief that an abscess is present, the soft tumour substance bears a striking resemblance to pus. Spread may occur and deposits appear in other

bones, a feature unusual in other types of sarcomata Death may eventually occur from lung metastases.

Radiologically the tumour causes an *osteolytic lesion* in the bone (Fig 18 40). In some cases the periosteum is stripped up and new bone laid down beneath it in laminated layers This is called the "onion peel" appearance but is not typical of any one pathological condition and is sometimes seen in osteogenic sarcoma and in osteomyelitis.

Treatment The tumour is extremely radiosensitive and may disappear completely after treatment. The prognosis therefore is reasonably good and some patients may survive for many years, although others die in a few



FIG 18 40 RETICULUM-CELL SARCOMA OR EWING'S TUMOUR.

months. Amputation is not required unless a fracture occurs at the site of the tumour

Multiple Myelomatosis (*Kahler's Disease*) This is a somewhat rare condition, occurring usually between the ages of forty and sixty and may be classified as a primary malignant tumour of the bone-marrow It originates particularly in the bones which normally contain red marrow and so is most frequently found in the vertebræ, sternum and the ribs. The pelvic bones and the skull, however may be affected The multiple tumours are independent growths, appearing simultaneously in a number of different bones as small nodules which vary in size from that of a pea to that of a hen's egg. The bone is gradually destroyed and its place is taken by a soft greyish-red mass. The cells composing this mass consist of primitive types arising from the same cells as those found in the blood In some cases the cells of this disease resemble plasma cells, and in the very rare examples where a single focus of this disease has been recorded without any disease whatever of other bones, it is this cell type that has been present, the so-called

plasmacytoma In the skull (Fig. 18 41) the growths appear as multiple clear areas of varying size. The disease first manifests itself by pain and men are more often affected than women. The pain usually in the back becomes persistent, and kyphosis may develop and slight fever may occur Pathological fractures are common, particularly in the ribs and vertebræ. Bence Jones proteosuria may be present. Secondary anæmia soon appears, and the patient dies of general cachexia with deposits scattered throughout the skeleton The diagnosis is confirmed by the X ray appearances in the bones and by finding the characteristic plasma cells in a specimen taken by biopsy or marrow puncture.



FIG. 18 41 MULTIPLE MYELOMATOSIS OF THE SKULL.

Treatment This is only palliative, temporary relief from pain and diminution in the size of the deposits being obtained by X ray therapy Urethane may also offer temporary palliation.

Other Bone Tumours. *Hæmangioma* A hæmangioma of bone rarely causes symptoms. It tends to occur in the vertebræ.

Chordoma. This rare tumour is described with tumours of the spinal cord It has malignant characters and arises from remnants of the notochord

Adamantinoma This develops from the enamel-forming organ of the teeth. It commonly occurs in the lower jaw and is described in Chapter 29 A histologically identical tumour occurs in the tibia and in association with the pituitary it is probably a basal-cell carcinoma.

Secondary Tumours of Bone. These may be carcinoma or sarcoma.

Metastatic Carcinoma This may occur as a direct extension from a primary growth, as when a carcinoma of the floor of the mouth extends into the lower jaw The usual method of spread, however is by the blood stream. The growths are usually endosteal and osteolytic (Fig. 18 42) except in the case of prostatic carcinoma which typically produces osteosclerotic deposits (Fig 18 43).

Spontaneous fracture may occur The most usual sites for the primary



FIG. 18 42 CARCINOMA OF THE BREAST
Osteolytic metastasis in the ischial bone.



FIG. 18 43 CARCINOMA OF THE PROSTATE
Osteosclerotic metastases in spine and pelvis.

growth are the breast, prostate, lung, kidney and thyroid. The bones most often affected are skull, vertebræ, ribs, pelvis, humerus and femur In carcinoma of the breast and prostrate, treated by hormones such as testosterone or stilbœstrol, the bone deposits may sclerose and heal if only for a

time. In these circumstances, pathological fractures in the humerus or femur may be treated on general lines in the expectation of union

Metastatic Sarcoma Sarcomata tend to produce metastases in the lungs, and deposits in bone are less common than in the case of carcinomata.

Cysts in Bone

Solitary Bone Cyst. Solitary cysts are met with occasionally in the shaft of the humerus or femur They occur in children and adolescents and are usually discovered accidentally when a fracture occurs through the thin



FIG. 18.44 PATHOLOGICAL OR SPONTANEOUS FRACTURE THROUGH A SIMPLE BONE CYST IN THE HUMERUS OF A CHILD.
The cyst has been filled with bone chips.

cortical wall. When opened the cyst contains loose strands of fibrous tissue and histological examination reveals a few osteoclasts The callus produced by the fracture may be sufficient to obliterate the cyst if small but large cysts may require curettage and packing with cancellous bone chips.

The fact that these cysts contain giant cells may lead to the belief that they are related to osteoclastoma, but the age of appearance and situation in the bone are different. The radiological appearance of a " cyst " in bone may be due to a solitary cyst, an enchondroma, an osteoclastoma or local fibrocystic disease, in addition to cysts due to a parathyroid tumour

Hydatid Disease of Bone. The cancellous tissue of bones occasionally becomes the site of hydatid development, any part either of the medullary cavity or of the ends being involved. The bone becomes expanded, with all the symptoms of an endosteal growth. Considerable deformity may occur and when the compact layer has been sufficiently absorbed, spontaneous fracture may follow In this affection there is no limiting wall, the small daughter cysts being diffused through the affected area. Radiography and laboratory tests should suffice to ensure a diagnosis, but in countries where

hydatid disease is rare the condition is very liable not to be recognized until an exploratory incision has been made

Treatment If all the cysts can be removed without interfering with the integrity of the shaft, a recovery with good subsequent utility of the limb, should follow Where, however the disease has encroached widely on the bony tissue resection with bone grafting, or amputation may be necessary

Section Three

THE SURGERY OF THE NERVOUS SYSTEM

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Chapter 19

THE PERIPHERAL NERVOUS SYSTEM

Injuries of Peripheral Nerves

Injuries are comparatively rare in civilian practice. Among battle casualties, however nerve injuries are common, and the experience gained in two world wars has added greatly to the knowledge of these lesions In particular the histology of repair has been studied, surgical technique has been improved, and the incidence of sepsis reduced by the use of antibiotics. The bridging of a long defect in a nerve trunk, however still remains a difficult problem.

Types of Injury A nerve trunk may be injured by

Contusion. The ulnar nerve for example is placed superficially at the elbow behind the medial epicondyle, and is liable to be contused in this situation There is a sensation of tingling, which usually wears off in a few hours.

Concussion This may happen when a high velocity bullet passes close to but does not directly injure the nerve trunk. Recovery takes place after a few weeks.

Compression. The nerve may be compressed by fibrous tissue or the callus of a healing fracture. Direct compression may occur from the pressure of splints or crutches (e g the radial nerve in the axilla), by tourniquets, or by tumours or aneurysms.

Division. In civilian life, the most usual example of nerve division occurs at the wrist, where the median or ulnar nerves may be cut by glass, or in attempted suicide. In addition, there may be tendon injuries. In puncture wounds the greatest care must be taken to exclude injuries to nerves, which are easily overlooked. At the moment of injury a shooting pain like an electric shock may be felt.

Traction. The classical example of this type of injury is that of the brachial plexus known as Erb s palsy This may occur during a breech delivery (p 535)

Interruption of Conductivity As a result of injury the conductivity of the nerve is impaired. The reasons for this are not always the same. Seddon has suggested a terminology to describe three types of nerve lesion

Neuropraxia (*Non-action*) This is a disturbance of short duration, affecting mainly the myelin sheaths. The paralysis is motor rather than sensory The nerve trunk and axons remain in continuity and recovery is to be expected in a few days or weeks. Neuropraxia is likely to result from contusion or concussion.

Axonotmesis (*Cutting of the Axons*) The nerve sheath is in continuity but the axons are damaged. Spontaneous recovery is to be expected, because the endoneural tubes are intact and can guide the growing axons to their destination. Nevertheless, complete motor and sensory paralysis occurs,

so that it may be impossible to distinguish this lesion from division of the nerve trunk unless exploration is undertaken. Axonotmesis is likely to occur when a peripheral nerve is involved in a closed fracture.

Neurotmesis (*Cutting*). The nerve is completely divided or if it appears to be in continuity is blocked by scar tissue. Recovery is impossible without surgical repair The nerve may be divided in wounds, or complete interruption may occur due to fibrosis, which is the result of traction injuries, or sometimes from the injection of irritating drugs into the nerve (e.g penicillin, gold salts, etc.) Ischæmia may also produce neural fibrosis (e g Volkmann's ischæmia, p 173)

Effects of a Nerve Lesion. These must be considered in relation to (a) the type of nerve involved, whether motor sensory or mixed (b) The type of nerve lesion, e.g neuropraxia, axonotmesis or neurotmesis (c) The effects of vasomotor and sudomotor paralysis and (d) Complicating factors, especially sepsis.

Immediate Effects The immediate effects are (a) Motor paralysis of the muscles supplied by the nerve (b) Anæsthesia of the area supplied by it; (c) Vasomotor paralysis. The part may at first feel warm but soon becomes cold and (d) Sudomotor paralysis. There is a cessation of sweating and the part feels dry

Prolonged interruption of conduction in a nerve will lead to secondary changes in the skin, muscles and joints The skin becomes atrophic, the nails ridged and brittle the pulp of the fingers wasted. Muscles become fibrotic and lose all power of contraction. Joints become stiff

Changes in the Nerve When a nerve is divided the ends retract and the space thus formed fills with blood. The clot so formed is replaced by granulation tissue. In time the cut ends unite by a strand of fibrous tissue through which no axons can pass. A bulb-like mass of scar tissue containing axons coiled in a disorderly fashion, forms on the end of the central stump (*terminal neuroma*) After an amputation most of the divided nerves are found to develop these end-bulbs, which may become adherent to the suture-line or be compressed by the socket of the artificial limb In these circumstances they may become the source of severe neuralgic pain (Fig. 19 1). The distal

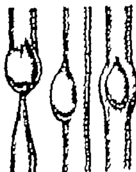


FIG. 19 1 NEUROMATA ON A PERIPHERAL NERVE.

stump may also develop a small bulb which consists of fibrous tissue only

In the peripheral portion of the nerve, the changes known as Wallerian degeneration start about the fourth day after injury The myelin sheath breaks up into irregular masses, which are absorbed and disappear entirely after about a month. The axons degenerate and disappear The endo-

neural tubules, which guide the axons to their destination shrink considerably and this may be a cause of delay or failure of remyelination of the growing axons, after nerve repair The cells of the neurilemma (Schwann cells) proliferate and it is these cells which bring about the union of a sutured nerve. The power of conduction of nervous or of electrical stimuli, is lost

Changes in the Muscles When a motor nerve is divided complete paralysis of the muscles it supplies, results. The paralysed muscles waste and the fibres degenerate All tone is lost Progressive fibrosis occurs so that in about a year the muscle belly may be replaced by a mass of inert fibrous tissue. When this has occurred there can be no hope of recovery Paralysed muscles may become elongated if put on the stretch by the weight of a limb or by the unopposed action of the normal muscle groups. If under no tension, however they tend to shorten.

Electrical Changes (*Reaction of Degeneration*). A normal muscle will contract when stimulated with a faradic (short duration) current. A denervated muscle fails to contract after two to three weeks. Contraction may still be obtained by a galvanic (long duration) stimulus but, as time passes, the amount of current (milliamperes) required to produce a contraction, has to be increased When a certain volume of current is reached it becomes too painful to continue the test. After about a year testing by galvanism, with the patient anæsthetized, may fail to produce any contraction. This corresponds to the time when the muscle has become fibrosed the power of contraction will not return, even if nerve conduction is eventually restored.

The use of the electromyograph allows the changes in denervated muscle to be followed more exactly enabling a more accurate prognosis to be given.

Changes of Sensation. There is loss of sensation in the area of supply of the damaged nerve The sensory loss applies equally to skin sensation and the deep sensation of tendons and joints. The tendon reflexes are lost. Lack of sensation favours the development of sores or ulcers at sites of pressure (*e g* the heel in a case of sciatic paralysis) These are sometimes called trophic ulcers. The loss of sensation may not coincide entirely with the anatomical distribution of the divided nerve This is because there is a certain amount of overlap from neighbouring intact nerves.

Vasomotor and Sudomotor Changes The blood supply to the paralysed part is diminished so that the extremities become cold and pale or bluish in colour Chilblains and sores readily develop and the unwise application of heat may cause a blister or slough. Wounds heal poorly and ulceration from slight irritation is likely (*e g* the corneal ulcer after a lesion of the fifth cranial nerve or the perforating ulcer of the foot after a sciatic nerve lesion). In a child, growth may be impaired if the area of paralysis is sufficiently extensive

There is cessation of sweating, the extent of which can be mapped out by dusting Quinizarin on the skin. When the patient s body is heated in a chamber the dye becomes moistened by sweat and changes colour and the area in which there is no sweating is clearly mapped out. This test gives a guide to the area of cutaneous sensory loss. Testing can also be done by electrical methods, and by the use of thermocouples to measure skin temperature.

Incomplete Division. This is not uncommon, especially in wounds produced by the penetration of fine cutting instruments, or of small conical bullets or of fragments of high-explosive shells.

Should the nerve be notched the divided fibres retract and leave a gap

which, after a time, is filled by a fibrous mass permeated with axis cylinders, constituting a *lateral neuroma*, over which are spread the undivided fibres of the nerve. This neuroma may be adherent to the scar tissue which reaches the skin and may be the site of severe neuralgic pain.

A large nerve trunk is sometimes penetrated by a small fragment of metal or missile, and some of its central fibres divided. In such cases a *central neuroma* may develop around which pass the healthy nerve fibres, and the bulbous enlargement so produced can often be felt from outside, and may be freely movable.

The phenomena resulting from partial division of a nerve vary considerably. Certain groups of muscles are more liable to be affected than others supplied by the same nerve and this is to be explained by the fact that there is a definite arrangement of the various bundles of fibrils in the nerve, and some portions of the nerves are more exposed to injury than others. Thus the fibres running in the sciatic nerve to the lateral popliteal division are external to those constituting the medial popliteal division, and are thereby more liable to be injured. Details of the arrangement of the fibres in different nerves must be sought in books on neurology.

Partially divided nerves are sometimes the site of persistent and serious irritation, especially if a fragment of glass or metal remains embedded at the site of the lesion. Trophic phenomena, often serious, may then appear in the distal parts supplied by the nerve. The skin becomes thin, atrophic, bluish-red and shiny ("glossy skin" of Weir Mitchell), the subcutaneous fat is absorbed, the hairs fall out, the nails become rough, brittle and scaly and there is increased sweating. The bones atrophy, joints become ankylosed, and ulcerative lesions occur on the slightest provocation.

In other instances, pain is the most marked feature, especially in partial lesions of the median and sciatic nerves. The pain is of a burning character (*causalgia*) felt in the palm of the hand or sole of the foot, and brought on by touching the part, or by emotional stimuli, such as sudden noises. It is usually increased by even moderate degrees of heat or cold, and by any movements which drag on the nerve. It prevents sleep and is very intractable. The symptoms may be relieved by lumbar sympathetic block or ganglionectomy.

Wound Infection. This adds a grave element to the damage caused by injuries to nerves. The exposed nerve-ends suffer equally with other tissues in the early destructive and later reparative processes necessary to combat infection. The development of scar tissue, moreover, introduces a barrier between the divided ends of the nerve.

Clinical Examination of Nerve Lesions. It is important that a thorough examination be carried out as early as possible after the accident. Only the simplest apparatus is required but the examination should be carried out in a deliberate manner and in quiet surroundings, if possible in a separate room.

An intimate knowledge of the anatomy of the parts is essential. The findings must be recorded accurately and the examination must be repeated at intervals during the succeeding weeks so that the state of recovery can be measured. Upon these data the prognosis is formulated and the decision to continue with conservative treatment or to operate is determined.

The history of the accident may shed light on the type of nerve injury to be expected. Small puncture wounds may be associated with considerable

nerve damage Coexisting injuries, such as fractures or dislocations, must be noted.

Recording of Muscle Power The system of muscle grading recommended by the Medical Research Council is used This recognizes six grades

5. Contraction against powerful resistance
4. Contraction against gravity and some resistance.
3. Contraction against gravity only
2. Movement only with gravity eliminated
1. Flicker of contraction
0. Complete paralysis.

Sensory Loss Loss of sensation to pin prick and cotton wool should be recorded in a simple sketch. Areas of complete or partial loss may be shown by shading. The points of a compass may be used for estimation of two-point discrimination Routine testing for heat and cold sensibility are unnecessary Deep sensory loss and the positional sense of joints must also be recorded, together with the presence or absence of tendon reflexes.

Clinical Assessment. Four clinical syndromes are recognized

(1) *The Syndrome of Interruption.* This may be due to (*a*) Neurotmesis, or division of the nerve (*b*) Axonotmesis, or a lesion in continuity It is impossible to distinguish these on clinical grounds. In both, there is complete motor paralysis, sensory loss, and progressive atrophy of muscles or (*c*) Neuropraxia The paralysis is of short duration, muscle wasting and sensory loss are slight, but subjective sensation of burning or tingling are common. Recovery takes place in a few days or weeks.

(2) *The Syndrome of Compression.* The paralysis may be partial or complete. Muscle wasting is rapid but not so severe as in complete division and some tone may be preserved. Anæsthesia is patchy Electrical testing carried out after two to three weeks will help to differentiate these syndromes. In " compression " the reaction of degeneration will be incomplete.

(3) *The Syndrome of Irritation* Pain and burning are prominent features with tenderness along the course of the nerve. There are marked vasomotor changes with excessive sweating. The syndrome is associated with irritation to the nerve by foreign bodies, sepsis or partial nerve lesions. In its severe form, this syndrome is known as causalgia.

(4) *The Syndrome of Regeneration.* After division, regeneration can occur only when continuity has been restored. Continuity means not only that of the nerve trunk but of the axon tubules, down which the axons grow from the central end. The rate of growth is variable but may be accepted as about 1 mm. per day Obstacles to regeneration are a gap in the nerve, fibrosis at the site of union and shrinkage of the axon tubules. In addition, rotation of one portion of the nerve in relation to the other will lead the axons to arrive at a destination other than normal Calculation of the approximate time needed may be made by measuring the distance from the site of division to the motor point of the muscle, but this represents the minimum time in which regeneration is possible

Signs of Regeneration. Tinel's sign is elicited by pressure or percussion over the site of injury Tingling (formication) may be referred to the peripheral distribution of the nerve. When this sign can be elicited at a lower level it may be assumed that the axons have reached this point. The sign does not give any indication of the degree of recovery likely to take place.

ulnar nerve by transposition to the front of the elbow Another possible method is to shorten the bone or to attempt nerve grafting In any case the nerve should never be sutured under tension

(7) Great gentleness in handling the nerve is essential and during the operation it must be kept moist with warm saline.

(8) The best suture material is fine silk or thread Stainless steel wire may be used but is difficult to manipulate. Catgut should be avoided as it causes fibrosis.

When the operation fails, function may sometimes be restored by tendon transplantation but loss of tactile sensation remains a serious handicap

Incomplete Division When nerve division is known to be incomplete or is uncertain (neuropraxia or axonotmesis) conservative treatment is indicated and a period of time must elapse before it is known whether recovery will take place Help may be obtained by electrical tests

Conservative treatment consists of

(1) Maintenance of mobility of joints and muscle volume. Joints stiffen rapidly in a paralysed limb, particularly those of the fingers and thumb Passive movements must be given several times a day to prevent this serious complication This is specially important if a splint has to be applied.

(2) Muscle volume may be kept up by regular galvanic stimulation. This is only possible where a limited number of muscles has been paralysed.

(3) Paralysed muscles must not be overstretched The need for a splint, therefore, is to prevent overstretching of paralysed muscles rather than to obtain relaxation.

(4) When there is loss of skin sensation, the part must be protected from injury This applies particularly to the hand which is liable to be burned by cigarettes, hot kettles or in ironing. A glove should be worn. When the patient is in bed, great care must be taken to prevent burns by hot water bottles.

The duration of expectant treatment depends upon the progress of the case. If the lesion in the nerve is due to a physiological interruption (neuropraxia) recovery will be evident in a few weeks. On the other hand, if there are no signs of recovery it is evident that the lesion is more severe and may be either a lesion in continuity (axonotmesis) or a severed nerve (neurotmesis).

If it is thought likely that there is a lesion in continuity sufficient time must be given for the axons to regenerate and make connection with the motor end-plates or sensory organs. This time can be worked out on the basis of 1 mm. per day as the rate of growth with an allowance for delay in penetrating fibrous tissue and for the re-establishment of motor or sensory connections. Probably four to six weeks should be added to the time calculated by measurement. If no recovery is evident within the expected time, exploration of the nerve should be undertaken.

In open wounds, there is a 50 per cent. chance of the nerve being severed so that when any doubt exists it is better to undertake an early exploration rather than to wait. In this case the exploration should be done as soon as the wound has healed and induration has subsided (*i.e* probably in about four weeks).

To summarize, it must be realized that when anatomical interruption is present, there is progressive shrinkage of the distal nerve stump and progressive atrophy of the muscles supplied by it. It follows therefore that

early restoration of continuity is likely to be followed by the best functional recovery When doubt exists as to the state of the nerve, an early exploration is advisable Delayed suture at about four weeks is, on the average, better than primary suture.

LESIONS OF SPECIAL NERVES

The Cervical Plexus. The nerves constituting the cervical plexus are exposed to injury either from blows, dislocations of the cervical spine, penetrating wounds or during operations. No very serious results follow except in the case of the phrenic nerve, bilateral division of which may cause instant death by paralysis of the diaphragm. Unilateral phrenic crush is commonly employed in the treatment of pulmonary disease. A small supraclavicular incision is made and the nerve discovered behind the sterno-mastoid as it runs downwards closely applied to the scalenus anterior muscle.

The Spinal Accessory Nerve. This is occasionally divided in operations for the removal of tuberculous or malignant glands, and may cause serious deformity from tilting of the scapula and depression of the shoulder, especially if the branches of the cervical plexus supplying the trapezius are also severed

The Sympathetic Nerve Trunk. In the neck this is occasionally compressed by aneurysms, tumours and hæmorrhage in the thyroid gland. If irritated, dilatation of the pupil on the same side and unilateral sweating of the head and face are produced but, if divided, the pupil is contracted from unbalanced action of the third cranial nerve.

The Intercostal Nerves. These may be the site of severe neuralgia or referred pain arising from root irritation. Inflammatory lesions or neoplasms of the cord or neighbouring vertebræ may be the cause, while the neuralgia may be due to degenerative changes in the joints. Neuralgia following herpes zoster is another cause This may be difficult to treat but success has followed injection of the nerve with alcohol The twelfth thoracic nerve may be the site of severe neuralgia and follows its distribution to the anterior abdominal wall and buttock It occasionally leads to a mistaken diagnosis of an abdominal or renal lesion, and unnecessary operations have been undertaken in consequence. Occasionally in operations on the kidney the nerve becomes involved in fibrous tissue, and this causes troublesome pain.

The Brachial Plexus

Wounds The plexus may be injured in gunshot wounds or occasionally divided by cuts or stabs in the lower part of the posterior triangle. The accident will cause motor paralysis or loss of sensation corresponding to the particular nerves involved

Closed Injuries The majority of these are due to traction, but contusion or compression of the lower part of the plexus may be caused by the head of the humerus when dislocated into the axilla. The inner cord is usually involved. Attempts at forcible reduction of an unreduced dislocation of long standing may result in severe traction injuries both to the plexus and to the axillary artery

Traction Injuries These are the common injuries of civilian life The lesion may be complete or partial. Complete lesions occur as a result of severe traction as may happen in road traffic accidents. Partial lesions may

be of two types (*a*) Upper arm type (Erb-Duchenne paralysis) and (*b*) Lower arm type (Klumpke paralysis)

Upper Arm Type Paralysis. This may occur when the shoulder is depressed and the head forced to the opposite side. Road traffic accidents are sometimes responsible, as when a rider is thrown on to his shoulder from a motor cycle. Long continued hyperextension and abduction of the arm during an operation may also cause paralysis. The position in which the hands are placed behind the head or in which the arm is widely abducted and allowed to fall backwards into hyperextension are particularly to be avoided The anæsthetist must be especially watchful in this respect.

Obstetrical Paralysis (*Erb-Duchenne*) An upper arm type of traction injury may occur during delivery It is sometimes known as obstetrical



FIG. 19.2. A FAIRBANK SPLINT IN USE ON A NEW-BORN CHILD WITH BILATERAL ERB'S PALSY

paralysis and results from forcible stretching of the head sideways during vertex or breech deliveries. It is usually unilateral. The upper cords of the plexus are stretched and the main damage occurs in the fifth and sixth roots. The junction of these roots is known as Erb's point. The lesion occurs below the level at which the nerves to the rhomboid muscles and to the serratus anterior arise, so that these muscles escape. There is loss of power in the deltoid, spinati, biceps, brachialis, brachioradialis and sometimes in the wrist-extensor muscles. In consequence, the arm lies flaccidly to the side, in a position of internal rotation, and with the elbow extended, the forearm pronated and the wrist flexed (the " waiter receiving a tip " position) When recovery does not take place, fixed internal rotation may be evident and is due to overaction of the subscapularis and subsequent fibrosis in the front of the joint. There may be impairment of growth in the head of the humerus and the head of the radius, with deformity and a restricted range of movement in the shoulder and elbow Sensation is little affected and is limited to slight loss over the shoulder but this is difficult to detect in a small baby

The treatment is the application of the general principles of splinting to prevent overstretching of paralysed muscles, and prevention of joint stiffness and contracture by frequent passive movement. The Fairbank splint (Fig. 19 2) is made of malleable metal covered with leather It is strapped to the baby and a narrow portion can be bent to hold the arm in abduction, with the elbow flexed the forearm supinated and the wrist extended (the "waiter carrying a tray" position) A similar but less satisfactory position can be achieved by simply fixing the child's cuff to the pillow by a safety pin. The mother should remove the splint three or four times a day in order to put all the joints through a full range of movement, with special attention to external rotation of the shoulder

Recovery usually starts in a few weeks and is complete within three months, but if the lesion has been severe, the paralysis may be permanent. Exploration of the plexus confirms the presence of much interstitial and perineural fibrosis but nothing can be done to repair the damage.

Lower Arm Type Paralysis. This may occur when a person falls from a height and clutches at some object to save himself for example, a window cleaner falling and clutching at the window ledge. The lower cords are affected mainly those arising from the eighth cervical and first thoracic roots The intrinsic muscles of the hand (T I.) and the flexors of the wrist and fingers (C.8) will be paralysed. Claw-hand may result. There will be sensory loss over the ulnar distribution in the forearm and hand. If the lesion of the first thoracic root is very high, there may be sympathetic paralysis, with constricted pupil, ptosis of the lid and enophthalmos, together with dryness of the face and hand (Horner's syndrome) A similar lesion of the lower plexus, together with Horner's syndrome and pain radiating down the arm, may be encountered when the nerves are involved by a carcinoma of the apex of the lung (Pancoast's tumour).

The Circumflex Nerve. This is liable to injury from its exposed position, winding round the neck of the humerus about a finger's breadth above the middle of the deltoid. Blows upon the shoulder may in this way cause paralysis it is sometimes torn or compressed in fractures of the surgical neck of the humerus, or in dislocation of the shoulder and in these circumstances the injury may be overlooked Paralysis of the deltoid and teres minor follows, evidenced by inability to raise the arm from the side, whilst the wasting of the former muscle causes undue prominence of the acromion There may be anæsthesia over the posterior fold of the axilla.

Treatment When the fracture or dislocation has been reduced, the deltoid is tested by asking the patient to attempt to abduct the arm against resistance. This can be done without moving the joint. If paralysis is present, electrical stimulation is started, but it is unwise to apply an abduction splint for two or three weeks until the fracture or dislocation is stable. Recovery may be expected within six months but in a few cases the paralysis may be permanent.

The Radial Nerve. The nerve may be injured in dislocations or fractures of the shaft of the humerus involving the radial groove, and rarely in supracondylar fractures. Compression of the nerve may occur between a crutch and the bone (crutch palsy) or while lying asleep with the arm over the back of a chair as sometime happens after taking too much alcohol ("Saturday night" paralysis) Radial palsy is occasionally seen as a post operative complication, when the arms have b[een] ... bove the patient's head, and in

poisoning by heavy metals particularly lead and arsenic, in which case the paralysis is usually bilateral

The *posterior interosseus nerve* may be damaged as it winds round the neck of the radius where it lies in the supinator muscle The cause of the injury is usually a wound or an operation for removal of the head of the radius. Closed fractures of the radial neck are seldom accompanied by posterior interosseus nerve paralysis.

Symptoms Motor paralysis produces the following effects

(1) Extension of forearm When the lesion is high in the axilla the triceps muscle may be paralysed but with a lesion in the radial groove it escapes.

(2) Supination. There will be paralysis of the supinator and brachioradialis, but the biceps, supplied by the musculocutaneous nerve is also a supinator so that weak supination will still be possible. When there is a lesion of the posterior interosseus nerve at the level of the radial neck, the nerve to the brachioradialis escapes The muscle should always be tested, and can be seen to contract when the patient is asked to flex his elbow against resistance, with the forearm pronated.

(3) Wrist drop There is paralysis of the extensors of the wrist, thumb and fingers. The interphalangeal joints of the fingers can still be extended by the interossei and lumbrical muscles which are supplied by the ulnar nerve except for the lumbricals of the index and middle fingers which are supplied by the median nerve.

Anaesthesia is unimportant and when present is limited to a small area on the dorsum of the hand between the first and second metacarpals. Vasomotor changes are absent.

Treatment In the majority of closed injuries the lesion of the nerve is in continuity and is caused by a contusion or compression (axonotmesis) There is a very good chance of recovery and conservative treatment should be adopted

The wrist and fingers are supported by a "cock-up" splint made of plaster or better by some form of "lively" splint incorporating springs or rubber bands so that the fingers can be flexed and the joints kept mobile. All the joints of the fingers should be supported in slight flexion, and if a rigid splint is used, it need not extend more distal than the proximal phalanges. Provision must be made for a similar support to keep the thumb in extension. Mobility of the joints must be preserved by active and passive movements and electrical stimulation applied to the paralysed muscles.

If there is no recovery after the expected time, the nerve should be explored When the paralysis is caused by a fracture of the shaft of the humerus, it is possible that the nerve has been divided or nipped between the bone fragments. It may therefore be wise to explore early rather than late and to take the opportunity of stabilizing the fracture by internal fixation at the same time

Suture of a divided radial nerve is often remarkably successful, but when no recovery takes place, function may be restored by tendon transplantation. One example of this is to transplant the pronator radii teres muscle into the radial extensors of the wrist the flexor carpi radialis into the three extensors of the thumb and the flexor carpi ulnaris into the extensors of the fingers. Excellent function can be achieved Suture of a divided posterior interosseus nerve is rarely possible and tendon transplantation is the best solution to this problem.

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The Median Nerve. The nerve may be injured by gunshot wounds involving the arm or forearm. The common injuries of civilian practice occur at the elbow or wrist. At the elbow contusion is a frequent complication of the supracondylar fracture of childhood The nerve may also be injured when the elbow is dislocated. The paralysis may be incomplete and recovery is usually rapid. At the wrist, the usual injury is a cut, caused by thrusting the hand through a window falling on broken bottles or in suicidal attempts. The nerve may also be compressed in the carpal tunnel by swelling of the synovial sheaths of the tendons or by dislocation of the lunate bone this is described later under Carpal Tunnel Syndrome.



FIG. 19.3 MUSCLE WASTING SEEN IN A COMBINED MEDIAN AND ULNAR NERVE LESION DUCHENNE'S "APE HAND"

Symptoms The symptoms of a median nerve lesion must be considered in relation to the site of injury either at the elbow or at the wrist. In the latter case, the paralysis will of course be confined to the hand. When the lesion is in the region of the elbow the following changes will occur

(1) *Motor Paralysis* Paralysis of the pronator teres and pronator quadratus cause loss of active pronation of the forearm. Loss of the flexor carpi radialis results in weakness of radial flexion at the wrist and the hand will flex to the ulnar side Paralysis of the flexor pollicis longus causes loss of flexion of the terminal joint of the thumb, while paralysis of the flexor sublimis group results in weakness of grip The fingers cannot be clenched firmly into the palm. Flexion of the middle, ring and little fingers can be carried out actively by the corresponding slips of the flexor profundus muscle which are supplied by the ulnar nerve The exception is the index finger the sublimis and profundus muscles of which are both supplied by

the median nerve. When the patient is asked to clench his fist the index finger remains extended (the "pointing finger" of median paralysis). Loss of power in the palmaris longus produces little effect.

Motor paralysis in the hand is evidenced by weakness of the abductor pollicis, opponens pollicis half of the flexor pollicis brevis and the first lumbrical muscle. In consequence there is wasting of the thenar eminence, and loss of opposition and abduction of the thumb (Fig. 19.3) which lies flat in the same plane as the palm of the hand (Duchenne's "ape hand")

(2) *Sensory Loss* There is loss of sensation over the palmar aspect of the hand including the thumb, index, middle, and half the ring finger (Fig. 19.4) On the back of the fingers the sensory loss extends to the proximal

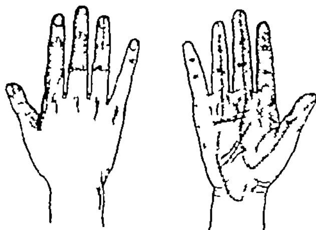


FIG. 19.4 SENSORY LOSS AFTER SECTION OF THE MEDIAN NERVE.
Light shading, hypo-esthesia dark shading, complete loss.

interphalangeal joints. In complete median nerve lesions, loss of tactile sensation may be more serious than loss of opposition of the thumb, which can be treated by tendon transplantation.

(3) *Vasomotor Changes* There is loss of sweating, resulting in a dry hand over the affected area. Trophic changes are marked, with wasting of the pulp of the fingers, brittle nails and sometimes ulceration.

Partial division of the nerve may be associated with severe vasomotor disturbance and pain referred to the hand and fingers.

Treatment In most closed injuries, expectant treatment is all that is necessary and recovery takes place within a few months. The only splinting required is some simple device for holding the thumb in the position of opposition. When the nerve has been divided and suture has been under taken, complete motor recovery is rare, and permanent impairment of sensa tion is to be expected.

Carpal Tunnel Syndrome. The syndrome of median nerve compression is well recognized and is accompanied by tingling and numbness in the thumb, index and middle fingers together with some weakness of the thenar muscles supplied by the median nerve (especially the abductor pollicis). The symptoms may be worse at night, and women are affected more often than men In many patients the cause is synovial thickening of the tendon sheaths, which may be of unknown ætiology or due to rheumatoid disease In others, no cause can be found. Conservative treatment may be tried, and

is often successful. The wrist is immobilized by a plaster slab in the neutral position either by day or night. If this fails, division of the carpal ligament by open operation is usually successful in relieving the symptoms.

The Ulnar Nerve. This nerve is commonly injured at the elbow or wrist.

Injury at the Elbow The nerve is placed superficially in the groove behind the medial epicondyle and is liable to contusion, often in association with a fracture of the epicondyle Paralysis which may be only partial, is present immediately after the accident

Late or *delayed ulnar palsy* may appear months or years after an injury The cause may be fibrosis around the nerve which is found to be swollen and adherent to the bone. A similar condition is seen as a result of osteoarthritis of the elbow In children an injury to the epiphysis of the capitellum or radial head which produces a cubitus valgus deformity may be responsible. In these patients, transfer of the nerve to the front of the joint will usually relieve the symptoms of tingling and numbness, but severe muscle wasting is unlikely to recover

Injury at the Wrist The nerve is injured in an open wound, and there may also be injury to the median nerve and to the tendons. Occasionally the nerve may be compressed by a ganglion.

Symptoms With lesions at the elbow there are symptoms of

(1) *Motor Paralysis* There is loss of power in the flexor carpi ulnaris. A branch to this muscle leaves the main nerve slightly above the epicondyle so that sometimes it escapes When paralysed there is weakness of ulnar deviation of the wrist. The flexor profundus group move the middle, ring and little fingers There is inability to flex the terminal joints of these fingers and some impairment of grip Paralysis also affects all the interossei muscles and the lumbricals of the little, ring and sometimes the middle finger

The muscles of the hypothenar eminence are also paralysed so that there is loss of abduction and adduction of the fingers. In partial nerve lesions, this may be most marked in the little finger The muscle wasting can be clearly seen especially that of the first dorsal interosseus as it lies on the radial side of the second metacarpal. Paralysis of the inner interossei and lumbricals results in the "main-en-griffe" deformity or clawing of the ring and little fingers, which are hyperextended at the metacarpophalangeal joints and flexed at the interphalangeal joints (Fig. 19.3)

Lastly the deep muscles of the thenar eminence are affected. The deep head of flexor pollicis brevis adductor pollicis obliquus and transversus, and palmaris brevis. The thenar eminence is wasted. The thumb cannot be adducted against the second metacarpal When in the ape hand position, the patient tends to flex the terminal joint when attempting to grip a card or sheet of paper

(2) *Sensory Loss* This is complete over a small area on the ulnar border of the little finger and partial over the remainder of the little and half the ring finger and the ulnar border of the hand (Fig. 19 5). When the lesion is at the wrist the dorsal branch of the nerve escapes since it arises above the wrist joint so that there is no sensory loss on the dorsal aspect. The motor paralysis is confined to the hand.

(3) *Vasomotor Changes* These are only marked in the little finger

Treatment Conservative measures include galvanism to the paralysed muscles and the application of a splint to control hyperextension of the

metacarpophalangeal joints. This is known as a "knuckle-duster" splint and consists of a bar lying across the palmar aspect of the joints connected to two dorsal bars. These lie, one over the metacarpal necks and the other over the dorsal aspect of the proximal phalanges. The dorsal bars are joined rigidly together and the palmar bar is attached to them by elastic.

Operative treatment may be necessary for nerves which are divided, or for transferring the ulnar nerve to the front of the elbow joint. The prognosis after ulnar nerve suture is only fair, being better after low than high lesions.

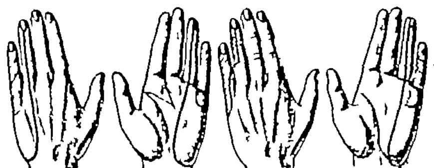


FIG. 19.5 SENSORY LOSS AFTER DIVISION OF THE ULNAR NERVE. Darker area shows complete loss of sensation.

The Sciatic Nerve

This nerve is frequently injured by gunshot wounds but in civilian practice, sciatic nerve injury is an uncommon accident. When injury does occur it is usually in connection with a posterior dislocation of the hip joint, with fracture of the posterior margin of the acetabulum. The lesion may be incomplete. The axons which are to form the lateral popliteal division are situated on the outer surface of the main trunk so that the paralysis affects the muscles of this division rather than those of the medial popliteal nerve.

When the injury is below the gluteal fold, the hamstrings are not paralysed owing to the high level at which their nerve supply arises from the main trunk. In this case, the paralysis resembles that found in lesions of the lateral or medial popliteal branches. Incomplete sciatic lesions are sometimes complicated by the severe burning pain of causalgia, which may be experienced in the sole of the foot.

In cases where the paralysis persists in spite of treatment, improvement in the gait may be secured by the use of an appliance to control the drop foot, or by arthrodesis of the ankle. Amputation has a place in treatment when the paralysis is complete or the trophic changes are severe.

The Lateral Popliteal Division. This may be divided during a subcutaneous tenotomy of the biceps, to which it lies immediately medial or compressed, as it winds round the neck of the fibula, by strapping, plaster bandages or splints. It may also be injured in fractures of the neck of the fibula. It is frequently injured in gunshot wounds, three times as often as the medial popliteal nerve. Total division causes sensory loss over the dorsum of the foot, and a varying part of the front and outer side of the leg, together with paralysis of the extensor and peroneal groups of muscles. In

the earlier stages inability to dorsiflex the foot results in "foot-drop" but later the contraction of the unbalanced opposing groups results in the paralytic form of talipes equinovarus.

The Medial Popliteal Division. This is much less exposed to injury owing to its more sheltered position. Division results in paralysis of the calf muscles, plantar flexors of the foot and flexors of the toes and of the short muscles of the sole The deformity of paralytic talipes calcaneovalgus is likely to follow There is sensory loss over the sole of the foot and heel, the plantar surface of the toes and the dorsal aspect of the outer four toes. Loss of sensation over the heel may sometimes be followed by "trophic ulceration and when this is severe, considerable disability may result.

The Tibial Nerves. If these are divided, the resulting effects are more limited thus, paralysis of the extensors of the foot and talipes equinus result from division of the anterior tibial paralysis of the short and long flexors of the foot and of the interossei with resulting talipes calcaneovalgus, follows lesions of the posterior tibial.

The prognosis after complete lesions of the sciatic, popliteal or tibial nerves is not good and only partial recovery may be expected, even after what is apparently a satisfactory nerve suture.

Tumours of Peripheral Nerves

True tumours of peripheral nerves are occasionally seen A tumour may arise from the Schwann cells and may be called a Schwannoma or neurinoma or consist of fibrous tissue, in which case it is a fibroma (Fig. 19 6). The tumours may be solitary or multiple The latter may be associated with pigmentation and tumours in the skin some of which contain nerve tissue

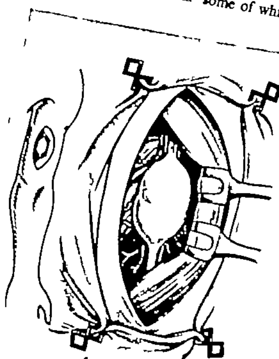


FIG 19.6. NEUROFIBROMA OF THE MEDIAN NERVE AS SEEN AT OPERATION.

and are painful and some consisting of fibrous tissue which are painless. Malignant changes may sometimes occur in them.

Neurofibroma This term is applied loosely to either type and the combination of multiple skin tumours and pigmentation may be familial and is known under the name of von Recklinghausen's disease (Fig. 8.4)

A peripheral nerve may sometimes be compressed by a ganglion and the symptoms may simulate a tumour of the nerve. For example, a ganglion arising at the wrist may compress the ulnar nerve or from the superior tibiofibular joint, the lateral popliteal nerve.

Chapter 20

THE AUTONOMIC NERVOUS SYSTEM

Anatomy

The history of our knowledge of the autonomic nervous system begins with François Pourfour du Petit who published, in 1727 an account of the changes he had noticed in the dog following the division of the vagosympathetic trunk. Five years later the Danish anatomist Winslow described the ganglia of the sympathetic nervous system and at the beginning of the nineteenth century Bichat put forward the hypothesis that the autonomic and the central nervous systems were two independent structures functionally which was in fact partly the truth.

A proper understanding of the physiology of the autonomic nervous system and the means whereby operations upon it could be used with advantage in man, evolved from the work of von Haller in Germany Leriche in France and Gaskell and Langley in Britain. Their experiments established the anatomical pathways by which the impulses were transmitted and the effects which they produced.

The autonomic nervous system is anatomically made up of two main parts the sympathetic or thoracic outflow and the parasympathetic or cranio-sacral outflow These two systems to some extent have opposing actions thus stimulation of the sympathetic nerves causes vasoconstriction in blood vessels throughout the body (with the exception of the coronary arteries) and quickening of the heart rate, and dilatation of the bronchi, while stomach and intestines become inhibited both in muscle movement and secretory activity Stimulation of parasympathetic fibres can cause vasodilatation, as for example in initiating erection of the penis, and can cause greatly increased peristalsis and secretion of digestive juices.

The sympathetic nervous system consists of (*a*) Preganglionic fibres, (*b*) Ganglionated trunks, (*c*) Visceral ganglia and (*d*) Postganglionic fibres

Preganglionic Fibres These fibres, also called the white rami communicantes arise from cells in the lateral horn of grey matter in the spinal cord between the first thoracic and third lumbar segments. They leave by the anterior nerve roots and pass to the ganglionated trunks. They may be interrupted and form a synapse in the ganglion at that level or pass up and down the trunk before doing so Other fibres pass through the trunk to arborize in the peripheral ganglia such as the visceral ones. From the ganglionated trunks *postganglionic fibres* or grey rami communicantes pass to all the somatic nerve roots for distribution to blood vessels, sweat glands, salivary glands and so on (Fig. 20 1).

Ganglionated Trunks These two trunks extend from the base of the skull to the coccyx as paired chains of ganglia receiving the white rami and giving off grey rami to the somatic nerve roots (Fig. 20 2). There are three cervical

ganglia, eleven or twelve thoracic and usually four lumbar and four sacral ganglia. Visceral ganglia such as the splanchnic, contain ganglion cells whose axons pass direct to the abdominal viscera, *i.e* postganglionic fibres The more important anatomical divisions of the autonomic system are mentioned below primarily because of their surgical importance It should be remembered that the white rami communicantes which are composed of preganglionic efferent fibres from the first thoracic to the second lumbar segment inclusive also contain a certain number of afferent fibres

Stellate Ganglion. This consists of the fused inferior cervical and first thoracic ganglia and forms an irregular mass of variable size In performing a sympathectomy of the upper limb it is necessary to define not only the

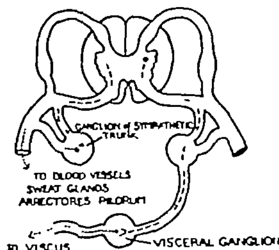


FIG 20.1 THE CONNECTIONS OF THE SYMPATHETIC CHAIN WITH THE SPINAL NERVE. The preganglionic and postganglionic fibres are shown in their relation to the gangliated trunk.

stellate or cervicothoracic ganglion, but also the second thoracic ganglion since the latter frequently sends a contribution called "Kuntz s nerve" which runs either direct to the first thoracic spinal nerve or to the first thoracic nerve *via* a branch from the second thoracic nerve The stellate ganglion lies anterior to the spinal nerves in a groove on the neck of the first rib

Lumbar Ganglia. These are usually four in number and are found on each side of the midline, those on the right being overlapped by the inferior vena cava and those on the left having a close relation to the aorta. The ganglia are not constant in size or position but the uppermost usually lies a little above the renal pedicle The lumbar ganglia give off branches to the pre aortic plexus which is a dense irregular network of nerve fibres lying over the aorta. From this plexus collections of fibres form trunks passing to a number of structures and inferiorly forms the presacral nerve.

Presacral Nerve This nerve consists of sympathetic fibres which have come from the lumbar sympathetic ganglia. It lies on the anterior aspect of the fifth lumbar vertebra immediately beneath the peritoneum. It is really a mass of nervous tissue rather than a single nerve trunk. Distally it gives off two main bundles passing to each hypogastric ganglion.

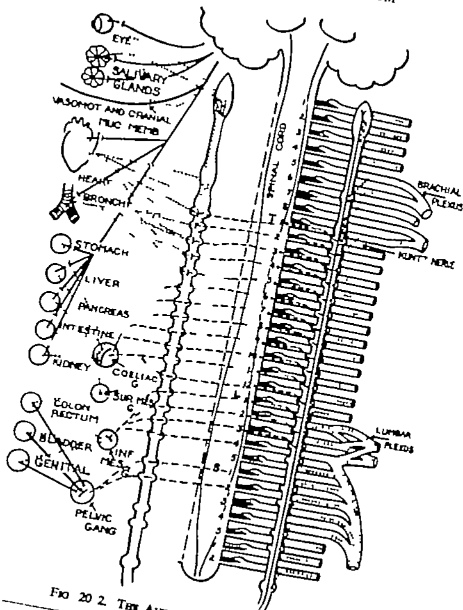


FIG 20 2. THE AUTONOMIC NERVOUS SYSTEM.
— = Preganglionic fibres.
- - = Postganglionic fibres.
— = Parasympathetic nerves.

Sympathectomy for Peripheral Vascular Disease

All operations upon the sympathetic nervous system consist of cutting or excising nerve trunks in order to release organs from sympathetic nervous control By far the largest number of these operations is done for peripheral vascular disease such as Raynaud's syndrome and thrombo-angiitis obliterans. Sympathetic fibres may also be divided in order to reduce sweating and for certain types of pain. A description of some of the more important peripheral vascular conditions which are treated in this way follows.

Tests for Peripheral Vascular Disease. Since sympathectomy can be extremely effective when applied in the treatment of suitable cases of

Raynaud's syndrome, and the choice of such cases requires the use of special tests, the more important of these are outlined below. Many of the other peripheral vascular diseases described below respond to sympathectomy if it is carried out at the right stage. These tests enable that decision to be made.

Reflex Heating Test. An indication of the capacity of the skin vessels to dilate can be obtained by measuring the rise of skin temperature when vasoconstriction is inhibited. The affected limb is exposed in a room kept at constant temperature and the skin temperature is then recorded by means of a thermocouple and galvanometer. When a constant temperature is recorded two of the unaffected limbs are placed in hot water or a heated cage is placed over the trunk, or the body is surrounded by a number of hot water bottles and the patient given a hot drink. Normally there is a rapid rise in the skin temperature in the ensuing half hour and the extent of this rise is an index of the capacity of the vessels to dilate. Alternatively vasoconstriction can be inhibited by intravenous injection of a ganglion blocking agent such as one of the methonium compounds or tetraethylammonium chloride.

Reactive Hyperaemia Test. This test is carried out while the limb is kept warm. A pneumatic pressure cuff is fastened on the upper arm, or may be used on the thigh and the circulation is then occluded for several minutes. On releasing the pressure the skin flushes and the blood flow can be judged by the rapidity with which this flush spreads. In a healthy limb this takes place in about five seconds but there may be great delay when the vessels are diseased.

Plethysmography. This is a technique for measuring the volume of blood flowing through a finger or toe or it may be applied to a larger part of the limb. The finger or hand is placed inside a glass or plastic cup which is firmly attached so that the whole is sealed off. When the veins are compressed the volume is increased and it is possible to calculate the volume flowing through the part. The method is a most accurate and sensitive one and gives very valuable information of blood flow.

Oscillometry. This is the technique of measuring pulsations in the main artery of a limb by placing around it a pneumatic cuff which is then inflated. To the latter is attached a further pneumatic cuff from which small oscillations can be measured by a manometer or moving needle. The Pachon oscillometer is the one in common use, and although not very sensitive, it is a valuable instrument for use at the bedside.

Arteriography. In this form of investigation a radio-opaque fluid, usually 60 per cent. diodone, is injected proximally into one of the main arteries and serial skiagrams are taken of the limb as the dye is swept through the circulation. The injection may be made percutaneously or after exposure of the artery at open operation. Considerable skill is required in injecting the dye quickly enough and in the correct timing of the radiographs. The technique offers the most direct method of seeing the anatomy of the vessels supplying the part, but it has limited application when applied to the smaller arteries.

Raynaud's Syndrome. This condition is seen almost exclusively in women. It produces intermittent spasm of the digital arteries, usually of the hands and more rarely of the feet. There may be nutritional lesions of the fingers but there are no primary structural changes in the vessels themselves. In a typical attack the circulation to one or more fingers becomes arrested where

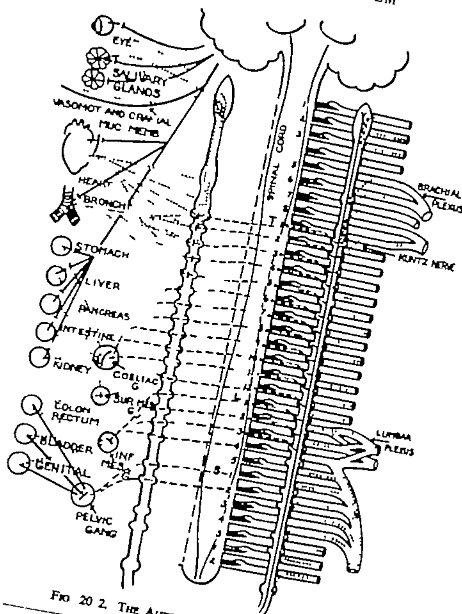


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upon the tissues become white and numb The return of the circulation is accompanied by quite severe pain and there may be considerable stasis in the vessels. Attacks are usually induced by exposure to cold and may vary widely in their severity In the minority of individuals the condition is progressive and the attacks lead to patchy necrosis of skin and soft tissues with tapering of the fingers and even loss of the phalanges.

It is considered that the disease is due to an abnormal response on the part of the arteries to cold and that there is no abnormality of nervous control of the blood vessels. Raynaud's phenomenon may be superimposed upon blood vessels which are already diseased and it is therefore necessary to exclude such conditions as arteriosclerosis, thrombo-angiitis obliterans, pressure of a cervical rib on the subclavian artery and emboli. The prolonged use of pneumatic tools may induce a change in the digital vessels which is indistinguishable from Raynaud's phenomenon.

Treatment The treatment of mild cases of Raynaud's syndrome is adequate protection against cold Warm dry woollen or fur gloves are worn out of doors and should the hands be chilled they should be warmed gently in warm water or by friction and never exposed to a severe heat. All injuries to the digits should be most carefully avoided. In suitable patients with Raynaud's syndrome, *i e* those in whom the vessels are capable of dilation, sympathectomy offers an excellent form of therapy By abolishing normal vasoconstrictor tone it makes the vessels less likely to be constricted and in the less severe cases permanent improvement can be expected. Where, however the disease has been accompanied by permanent changes in the vessel walls or soft tissues, the results are not likely to be good and may in fact be disappointing.

Arteriosclerosis. In this condition, which has already been described, sympathectomy may offer some temporary relief by increasing the blood flow through the collateral vessels which develop in response to the blockage of a main artery

Buerger's Disease. This condition is also called thrombo-angiitis obliterans. It is a disease which affects men almost exclusively and the lower limbs are usually the first to be involved The condition is a progressive one and usually occurs in distinct attacks. There is a superficial phlebitis and a concurrent thrombosis of the peripheral arteries. The patient usually complains first of intermittent claudication which is a severe cramp-like pain in the back of the legs following exercise relieved by rest and brought on again by further exercise. The distance which the patient can walk before developing the pain is called the claudication distance. The cause of Buerger's disease is unknown but it is aggravated by cigarette smoking and this should be forbidden Frequently the patient is unwilling to give up smoking even when he knows that amputation of a limb is likely to be necessary if he persists.

The diagnosis of Buerger's disease is made in men when there is bilateral involvement, the lower limbs being mainly affected and from special tests which should include paravertebral block and, if possible, arteriography A paravertebral block consists of paralysing the sympathetic chain in the lumbar region. A needle is introduced lateral to the spine, passed obliquely forward through the psoas muscle and procaine is injected to block the sympathetic fibres If good warming of the limbs results from this, a sympathectomy should be carried out, since a considerable part of the impaired circulation must be due to spasm of the peripheral vessels.

Erythrocyanosis. This is a condition seen typically in the legs of young women There are large areas of purplish or bluish skin discoloration and the skin feels cool and may be tender to the touch The pain is increased on warming, nodules appear in time and these may even ulcerate The skin capillaries appear to be widely dilated and contain stagnant blood while the arterioles are constricted The treatment for most of these patients is protection against cold by wearing suitable clothing, but where there is much pain and nodules develop bilateral lumbar sympathectomy is indicated

Acrocyanosis. Acrocyanosis is a milder degree of erythrocyanosis and is similarly seen in young women in whom the legs or arms, when exposed to cool air become purplish and red These patients also suffer from chilblains and the proper treatment is protection against cold. Sympathectomy may be called for Thyroid extract may help these patients and those with erythrocyanosis.

Erythralgia. This is not a specific disease in its own right but is a condition which complicates a number of pathological conditions in the limbs. It consists of pain tenderness to touch and redness of the skin when exposed to warmth It is most typically seen in " immersion foot " but may also be found in frost bite, burns and inflammation of the soft tissues. Warmth is contra indicated since it produces pain and the condition is severely disabling. Bilateral lumbar sympathectomy is often effective.

Poliomyelitis. Infantile paralysis can produce a limb which is wasted, blue cold and ulcerated because of the poor circulation through the tissues on account of disuse. The nutrition of such a limb can be greatly improved by sympathectomy which is especially indicated where trophic ulcers are present.

Sympathectomy for Other Diseases

There are many conditions, other than those affecting the peripheral vessels, for which sympathectomy may be used. Some of these are listed below but it should be noted that this is a field in which the indications for operation are constantly changing.

Sympathectomy for Angina Pectoris. The pain impulses of angina pectoris pass along the middle and inferior cervical and thoracic cardiac nerves to the upper four or five thoracic ganglia and then by way of the rami communicantes to the posterior roots and spinal cord The pain of angina may therefore be relieved by blocking these nerves by paravertebral injections of alcohol or by cutting the nerves, an operation which must be carried out by a transpleural approach. These patients are not usually good candidates for such an operation but when it can be performed the results are often excellent. It is usually only necessary to perform the section on the left side, but it may have to be bilateral.

Sympathectomy for Hypertension. Malignant hypertension, which is a progressive form of this disease accompanied by severe changes in the eyes and often seen in younger patients, has been treated by extensive sympathectomy operations. Many types of sympathectomy have been developed for this condition subdiaphragmatic by Adson, supradiaphragmatic by Peet, thoracolumbar by Smithwick and total by Grimson. In the operation introduced by Smithwick the sympathetic chain from the eighth or ninth thoracic to the second lumbar ganglion is excised together with the splanchnic nerves on both sides. The symptomatic results are good although the changes

in the blood pressure may be minimal. With the introduction of potent ganglion blocking agents such as the quarternary ammonium compounds and other drugs for lowering the blood pressure, these operations have been largely discontinued.

Sympathectomy for Pain. There are a number of indications when pain can be relieved by a suitably planned sympathectomy but for more detailed consideration of the surgery of pain the reader is referred to Chapter 26.

Causalgia In this condition, the exact pathology of which is still not properly understood, it is sometimes of value to carry out sympathectomy of a limb in which causalgia is present. The median nerve in the arm and the sciatic in the leg are the two nerve trunks most commonly affected. Symptoms are a severe burning pain accompanied by redness and sweating of the affected part. The reason why sympathectomy is of value is not known, but since the nutrition of the tissues in causalgia is often affected it may be that the improved circulation contributes to their recovery

Dysmenorrhœa Certain cases of spasmodic dysmenorrhœa which are unaccompanied by major gynæcological lesions may be relieved by sympathectomy The operation carried out is a presacral neurectomy and the choice of patients for this operation is difficult, since some obtain complete relief while others appear to be unaffected.

Renal Pain Certain forms of hydronephrosis and patients who have pain in the kidney region are relieved by stripping the renal artery which includes the removal of the sympathetic fibres which run in the adventitia. It is an operation which requires great patience but has been found to have a practical application in a small group of renal lesions.

Hyperidrosis. Some unfortunate individuals suffer from excessive sweating and this is usually initiated by emotional upset. The sweat may drip from the fingertips even when the patient is in a cool room and the disability can be a crippling one. Sympathetic denervation leads to complete cessation of sweat secretion and therefore is excellent treatment for these patients. Many of them, however require psychiatric therapy rather than sympathectomy and the operation should be reserved for those in whom all other treatment has proved ineffective.

The Operations of Sympathectomy

Upper Limb. Sympathectomy of the upper limb is carried out by dividing the sympathetic trunk below the level of the third thoracic ganglion and the white rami of T.2 and T.3 By this means the white ramus of T 1 is preserved and since this is distributed entirely to the head and neck a Horner's syndrome is not produced Operation is carried out by either an anterior or posterior route.

Anterior Operation. This approach is associated with the names of Gask and Ross. It is performed through an incision made horizontally above the inner half of the clavicle. After exposing the posterior triangle, the omohyoid muscle is divided and the scalenus anterior muscle cut across just above the first rib (Fig. 11 4) The vertebral artery is then displaced or divided between ligatures and after splitting Sibson's fascia the pleura is gently pushed off the sides of the vertebral bodies and the upper three ribs. The stellate ganglion is seen lying in the groove on the neck of the first rib and the trunk is traced down to below the third thoracic ganglion where it is

ligated and divided Its end may be turned upwards to discourage regeneration but it is unnecessary to enclose it in any kind of material

Posterior Operation. This is associated with the name of Adson and Smithwick. A vertical incision is made some 8 cm. long and 5 cm from the midline, over the inner ends of the second and third ribs. The trapezius rhomboid, levator scapulæ serratus posterior and sacrospinalis muscles are divided vertically preferably with the diathermy current and the posterior parts of the second and third ribs are then cleared and excised The pleura is then gently pushed forward from the vertebral bodies and the sympathetic trunk divided below the third ganglion The white rami can be most certainly divided by interrupting the second and third intercostal nerves just outside the intervertebral foramina

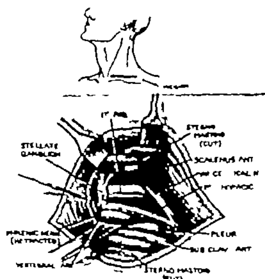


FIG. 20 3 THE ANTERIOR APPROACH TO THE STELLATE GANGLION. Note the relationship to the first rib. Insert shows the skin incision.

Lower Limb. Sympathectomy is carried out by removal of the upper three lumbar sympathetic ganglia. The operation may be done extraperitoneally through an incision in the loin or transperitoneally through a midline or paramedian incision The latter operation is reserved for those *patients in whom bilateral sympathectomy is to be done at the same operation.*

In the extraperitoneal operation the patient is laid on one side with a pad in the loin as for a kidney operation. An oblique incision is made from a point between the erector spinæ and the twelfth rib, downwards and forwards to the outer border of the rectus abdominis. The abdominal muscles are divided with the diathermy and the peritoneum, which is not opened, is stripped forward from the posterior abdominal wall (Fig. 20 4). The sympathetic trunk is found lying on the medial edge of the psoas muscle and on the right side it is overlapped by the inferior vena cava and on the left side by the aorta.

A neater but less roomy method of approach can be done with the patient lying prone. A transverse incision is made outwards from the outer edge of the rectus abdominis at the level of the umbilicus. The muscle layers are split or separated until the peritoneum is reached and this is then gently

pushed towards the midline. The sympathetic chain is generally found by palpation and then a lighted retractor is inserted so that the chain may be excised under direct vision.

The transperitoneal approach is carried out through a long left paramedian incision the small bowel is packed out of the way and the peritoneum is then incised to the lateral side of the descending colon on the left side and lateral to the ascending colon on the right. Mobilizing the bowel to the midline exposes the retroperitoneal space and the sympathetic chain is then found lying on the inner border of the psoas muscle. It is difficult with this approach to remove the first lumbar ganglion on the right side since it is covered by the duodenum and pancreas.

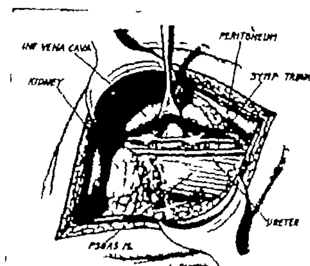


Fig 20 4. The Right Lumbar Sympathetic Chain Exposed from the Loin

Presacral Neurectomy A right lower paramedian incision is made, the abdomen opened and the patient tilted into the Trendelenburg position and the small bowel packed upwards out of the way A triangle is defined between the two common iliac arteries at the bifurcation of the aorta with a base situated over the sacral promontory The peritoneum over this triangle is picked up and carefully dissected away taking with it the dense connective tissue and interlacing nerve fibres which exist in this area. The middle sacral vessels require ligature and the nerves are then excised following the main trunk up to its origin near the inferior mesenteric artery

Splanchnicectomy This operation, otherwise known as thoracolumbar sympathectomy is now rarely performed, although it previously had a great vogue in the treatment of hypertension. It is carried out through a hockey stick incision made from the inner end of the tenth or eleventh rib vertically downwards 5 cm from the midline and then curving outwards below and parallel to the twelfth rib The eleventh or twelfth rib, or parts of both of them, are removed and the pleura pushed away from the vertebral body The diaphragm may be incised and then as extensive a removal as possible is made of the sympathetic chain An operation upon the opposite side is usually done after an interval of two weeks

Chapter 21

NEUROSURGICAL INVESTIGATIONS AND OPERATIVE PROCEDURES

Introduction

The successful practice of neurosurgery as with other surgical specialties, depends upon the ability of the operator to combine a knowledge of general surgical principles and high manual dexterity with an understanding of the medical aspects of the diseases he is called upon to treat. He must be familiar not only with the anatomy physiology and pathology of the nervous system but also with the methods of neurological investigation and diagnosis employed by his medical colleagues. When planning an operation the wise neurosurgeon seeks the advice and assistance of his neurological, radiological and neurophysiological colleagues, for such teamwork encourages success. However the responsibility for the operative attack and of the pre-operative and post-operative management rests upon his shoulders, and he must be able to weigh up for himself the various items of information and to make his own decisions.

Investigations

The diagnosis of organic conditions affecting the nervous system rests primarily upon the methods of careful history taking and of bedside examination developed by neurological physicians. Often, however the information obtained is uncertain or lacks precision Several special diagnostic methods have therefore been developed to amplify or sharpen the accuracy of neurological diagnosis. Among these methods are

(1) Examination of the cerebrospinal fluid (*a*) lumbar puncture, (*b*) cisternal puncture, and (*c*) ventricular puncture.

(2) Radiological procedures (*a*) straight skiagrams, (*b*) air encephalography (*c*) ventriculography (*d*) cerebral angiography and (*e*) myelography

(3) Electroencephalography including electrocorticography

Examination of the Cerebrospinal Fluid. Details of the circulation of the cerebrospinal fluid (Fig. 21 1) are given in physiological text books. The total volume in health varies from 120 to 150 ml., but its composition, quantity and pressure-relationships can be disturbed by a wide range of disease states. Examination of the fluid therefore not only yields information helpful to diagnosis, but also sometimes proves of therapeutic benefit. The methods available by which the fluid can be removed are lumbar puncture, cisternal puncture and ventricular puncture. The risks of the various methods are mentioned in the text.

Lumbar Puncture. This is the simplest and most commonly employed method. The patient lies on either side with his body well flexed. Under local analgesia and with aseptic precautions a special lumbar puncture needle, preferably sterilized by autoclaving, is inserted in the midline between

the third and fourth, or between the fourth and fifth lumbar spinous processes (the spinous process of the fourth lumbar vertebra is on a line joining the iliac crests) The needle is directed forwards and must usually be inclined slightly upwards. The spinal theca lies at a depth of between 5 and 7 cm. and, when it is penetrated, fluid will escape. Should bone be encountered the needle must be reinserted at a slightly different angle, or into another interspace. The intrathecal pressure should always be measured with a manometer and levels above 200 mm should be regarded as pathological. A little fluid can then be collected in a sterile container and submitted to the appropriate examinations, the cell and protein contents being tested routinely Following the puncture the patient should remain horizontal for several hours, rolling over on to his back or sides as feels most comfortable

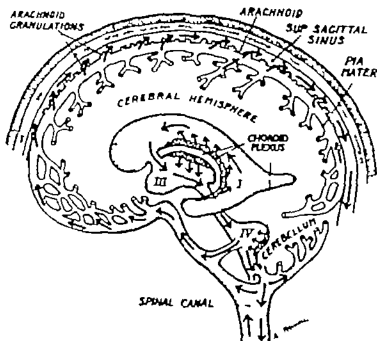


FIG 21 1 THE COURSE OF THE CEREBROSPINAL FLUID FROM THE CHOROID PLEXUSES IN THE LATERAL VENTRICLES TO THE ARACHNOIDAL VILLI IN THE SUPERIOR LONGITUDINAL SINUS.

The normal lumbar cerebrospinal fluid is crystal clear and contains 1–5 lymphocytes per c.mm. and 20–30 mg. of protein. Its characters, however vary greatly in different pathological conditions. Briefly in infections of the nervous system the cell content and the protein are raised, polymorphonuclear leucocytes appearing in pyogenic infections. With some cerebral tumours and with most spinal tumours the protein content is elevated without a corresponding increase of cells. In subarachnoid hæmorrhage, either spontaneous or post traumatic, the cerebrospinal fluid during the first few days is coloured red due to an even admixture with blood, and if it is allowed to stand the red cells will settle to the bottom leaving a yellow supernatant fluid In the later stages the cerebrospinal fluid will appear clear but yellow as it drips from the needle.

If lumbar puncture is performed in the presence of raised intracranial pressure, there is a risk that compression of the brain stem will develop due

to jamming of either the already downwardly-displaced cerebellar tonsils within the foramen magnum or of the uncinate gyri within the tentorial opening (pressure-coning) This leads to rapidly increasing coma. Lumbar puncture therefore should be avoided in known cases of raised intracranial pressure (as when an appreciable degree of papilloedema is present) or only carried out when the patient is on the threshold of a neurosurgical operating theatre. Again, if during a routine puncture an unexpectedly raised pressure is encountered the amount of fluid withdrawn should be limited to 2 ml. (an amount sufficient for most tests) and the patient nursed in the horizontal position for at least twenty four hours. If in spite of such precautions, pressure-coning develops, the urgent symptoms can be relieved by release of fluid from the lateral ventricles (ventricular tap)

In addition to its value in obtaining samples of fluid for examination, lumbar puncture is also used for introducing certain substances into the spinal theca. Such are antibiotic drugs, anæsthetic agents, and contrast media required for myelography

A useful observation in suspected cases of spinal cord compression or of thrombosis of the lateral venous sinus is the *Queckenstedt test* For this test a lumbar puncture needle of rather wide bore (*e g* Greenfield s needle) connected to a manometer should be employed Certain points of the technique as applied to spinal cord tumours are important and not being sufficiently widely appreciated, lead to false interpretations. First, the point of the needle must be cleanly placed within the subarachnoid space and not blocked by a flap of arachnoid or nerve root. This is checked by asking the patient to cough, or by manually compressing his abdomen when (even in the presence of a spinal block) a prompt rise of the pressure levels will occur followed by a prompt fall when the compression is released Then follows the crucial part of the test when the internal jugular veins in the neck are lightly compressed by the examiner s fingers for a period of ten seconds. The patient must be relaxed and continue to breathe quietly (otherwise the pressure levels will inadvertently be raised by abdominal compression) Normally within the first second the pressure level will begin to rise quickly and during a total period of ten seconds may rise 100 mm. or more followed by an equally prompt fall when the digital pressure is released. In cases of spinal block, however no rise of pressure occurs, or only a slight and sluggish rise. When lateral venous sinus thrombosis is suspected, the test should be modified by compressing only one internal jugular vein at a time, firstly on one side and then on the other However sometimes, even in normal people, no response will follow compression of the upper part of jugular vein. In such circumstances the patient should be turned over on to the other side of his body and the test repeated, before a diagnosis of a uni lateral sinus occlusion is made with certainty

A not uncommon, but avoidable complication of lumbar puncture is headache This is caused by leakage of cerebrospinal fluid through the puncture site in the theca into the loose extrathecal tissues, such leakage being particularly prone to occur with the increase of intrathecal pressure occasioned when the patient is erect. As long as the patient remains horizontal he feels well, but shortly after sitting up or standing he begins to complain of headache and nausea. Relief comes as soon as he lies down again and if lumbar puncture be repeated at this stage the intrathecal pressure will be found to be low (under 50 mm.) The treatment of this com-

plication is to keep the patient lying with the foot of the bed elevated for twenty four to forty-eight hours by which time the leakage will usually have ceased The patient can then be allowed to resume the erect position in graduated stages spread over several days.

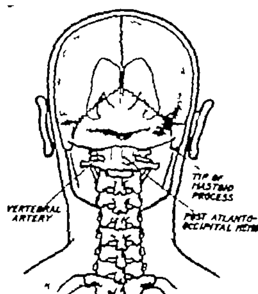


FIG. 21 2. THE SITE FOR CISTERNAL PUNCTURE.
A line joining the tips of the mastoid processes passes through the centre of the posterior atlanto-occipital membrane.

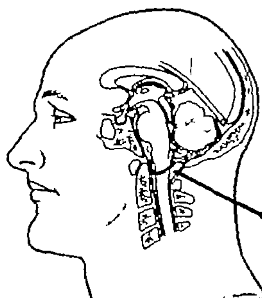


FIG. 21 3 CISTERNAL PUNCTURE.
The dark ring is the outline of the mastoid process.

Cisternal Puncture This is probably best left to the expert because of the risks of transfixing the medulla. *The technique is depicted diagrammatically* in Figs. 21 2 and 21 3 It is sometimes useful in the investigation

of spinal cord tumours (*e g* cisternal myelography) as an alternative route for air encephalography (cisternal encephalography) and occasionally as a route for introducing antibiotics in meningitis The normal cisternal cerebrospinal fluid is under the same pressure as the lumbar fluid but contains only from 10 to 20 mg. of protein

Ventricular Puncture It is necessary that as a preliminary burr holes be made in the skull except in infants when the lateral angle of the anterior fontanelle can be used instead Burr holes are usually sited in the parietal region, as depicted in Fig. 21 4 but sometimes frontal burr holes are used instead If the burr holes have been made recently a blunt nosed brain needle can be slid through the scalp wound into the lateral ventricle but if they have healed a sharp lumbar puncture needle is required instead Ventricular puncture is an essential part of ventriculography and the placing of the burr holes will be discussed more fully in that section Ventricular

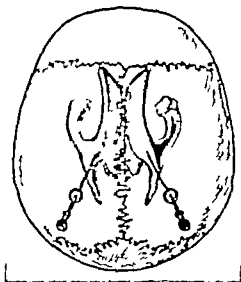


FIG 21 4 THE VENTRICULAR SYSTEM OF THE BRAIN FROM ABOVE.
The position of the ventricular puncture is shown.

puncture is also employed as an emergency procedure to correct the effects of pressure-coning and sometimes to introduce antibiotics into the lateral ventricles. Normally the intraventricular pressure is about 5 mm higher than the lumbar pressure, while the ventricular cerebrospinal fluid contains from 10–15 mg. of protein.

Radiological Studies of the Skull and Brain. *Straight Skiagrams* These must be good for indifferent X rays are worthless or misleading. Films taken in at least two planes are essential including a lateral view and a postero-anterior but an oblique antero-posterior (Towne's projection) and a full basal view are desirable for routine studies. In addition special views of the air sinuses, sella turcica, optic foramina, and the petrous bones can be obtained as required Stereoscopic views are optional.

Generally even in the presence of cerebral tumours, the skull pictures are normal. Osteomas and other tumours of the skull are readily revealed

(Fig. 21 5) Raised intracranial pressure of some duration usually leads to *decalcification and thinning of the dorsum sellæ and in children to enlarge-*



FIG. 21 5 OSTEOMA OF THE LEFT FRONTAL BONE INVADING THE FRONTAL SINUS.

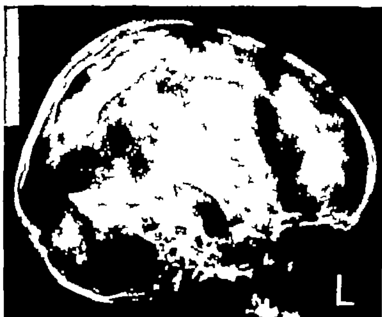


FIG. 21 6. RAISED INTRACRANIAL PRESSURE.

The skull of a child showing the beaten-copper appearance of the vault with spreading of the sutures. The ventriculogram shows hydrocephalus due to a partially calcified tumour in the posterior fossa.

ment of the skull with spreading of the suture lines and a beaten-copper appearance of the cranial vault (Fig. 21 6). The displacement of a calcified pineal shadow to one side is a useful pointer to a unilateral space-occupying

lesion Characteristic enlargements of the sella turcica occur in pituitary tumours (Fig 21 7) while often in the case of a *meningioma* of the cranial vault there is an endostosis (with sometimes an exostosis) surrounded by a conglomeration of abnormal diploic vascular channels (Fig 21 8)



FIG. 21 7 THE SKULL OF AN ADVANCED ACROMEGALIC.
An enormous sella turcica is seen and a very large frontal sinus.



FIG. 21 8. HYPEROSTOSIS OF THE SKULL OVER A MENINGIOMA SITUATED AT THE VERTEX.

Air Encephalography This is a method by which air is introduced into the ventricles and subarachnoid spaces, and then used as a contrast medium to outline these cavities in X ray films. A lumbar puncture (or sometimes a cisternal puncture) is performed with the patient seated in front of an X ray table with his head bent forwards 30 degrees to 50 degrees at the neck. Air (or oxygen) is slowly introduced in small quantities (5–10 ml at a time), displacing an appropriate volume of cerebrospinal fluid Care is required to keep the intrathecal pressure at a normal level throughout the procedure, for a marked fall in pressure will lead to severe headache, nausea, vomiting and sweating. Skiagrams are taken at intervals to check the progress of ventricular filling. Generally air introduced into the lumbar theca will pass up to the cisterna magna thence to the fourth ventricle and aqueduct and finally to the third and lateral ventricles (Fig. 21 9). Extending the head will

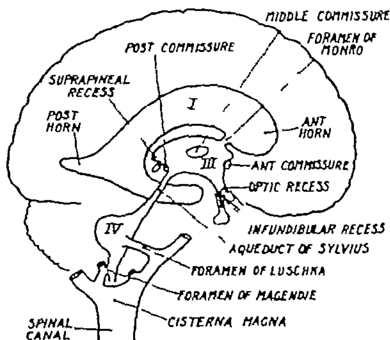


FIG 21 9 THE VENTRICULAR SYSTEM OF THE BRAIN AND ITS CONNECTIONS.

direct the air into the ventral basal cisterns and cerebral subarachnoid pathways. Usually not more than 30 to 40 ml. of air are necessary for outlining the ventricles.

The patient is then placed horizontally and a series of X ray films is taken in axial and lateral projections, firstly with the patient's head supine and then with his head prone. In this way the various parts of the ventricular system and the subarachnoid spaces are systematically outlined. Considerable experience is often required for interpreting the findings. A space-occupying lesion will produce a shift or distortion of the neighbouring ventricle (Fig. 21 6) A focal cerebral atrophy will lead to a localized dilatation of the ventricular system together with a focal enlargement of the adjacent subarachnoid spaces (Fig. 21 11). An obstruction to the ventricular system will cause enlargement from distension of the proximal portions of the ventricular system without corresponding subarachnoid space enlargement

When properly performed encephalography is a safe procedure which distresses the patient little and so can be performed under mild sedation with local analgesia for the lumbar puncture There is one chief contra indication and that is evidence of raised intracranial pressure (e g papill



FIG. 21 10. VENTRICULOGRAM SHOWING DISPLACEMENT OF THE ANTERIOR PARTS OF BOTH LATERAL VENTRICLES TO ONE SIDE INDICATING A SPACE-OCCUPYING LESION OF THE OPPOSITE CEREBRAL HEMISPHERE.



FIG. 21 11 ENCEPHALOGRAM SHOWING ATROPHY OF ONE CEREBRAL HEMISPHERE.

site and approximate size of a space-occupying lesion can often be inferred because of a localized displacement or distortion of cerebral vessels. Third, the actual vascular circulation of the tumour may be revealed and from the characteristics of such a "pathological" circulation the nature of the tumour can often be inferred (Figs. 21 13 and 21 14)

The performance of arteriography requires considerable experience and the technique is often elaborated to obtain additional views In skilled hands, however it is a safe and reliable method, and one which is now employed with even greater frequency than ventriculography The injected contrast solution is rapidly excreted in the urine. For cerebral tumour diagnosis it has the advantage over ventriculography that it does not disturb the intracranial pressure relationships, and so need not be followed promptly by operation. It has, however several blind spots, such as tumours within the ventricles, in the posterior fossa and in the deeper parts of the hemispheres, for these lie outside the carotid circulation



FIG 21 14 CAROTID ANGIOGRAM TAKEN DURING THE VENOUS PHASE, SHOWING UNIFORM OUTLINE OF THE TUMOUR STRADDLING THE SPHENOID RIDGE. (INTERENCE MENINGIOMA).

Radiological Studies of the Spinal Column. *Straight Sklagrams* As with X rays of the skull these must be of good quality taken in at least two planes, viz. lateral and antero-posterior Sometimes specially coned-down views are required to give greater definition in a region under suspicion. In scanning the films attention should be paid to the bony architecture for signs indicative of skeletal disease such as tumour vertebral body collapse, or tuberculosis for evidence of degeneration of the intervertebral discs with secondary osteophytic lipping, and for erosion of any of the pedicles of the various laminæ Undue widening of the *interpedicular distance is sometimes* the only radiological sign of a spinal cord tumour

Myelography This is employed in conjunction with lumbar puncture and the Queckenstedt test for the elucidation of spinal cord lesions. At the time of lumbar puncture 3–6 ml of a suitable medium such as Myodil are

introduced into the spinal subarachnoid space and the patient transferred to a tilting X ray table The contrast medium is heavier than cerebrospinal fluid and under fluoroscopic control it is made to travel up and down the spinal subarachnoid space by appropriate tilting of the X ray table Permanent records of any abnormality are obtained by exposing X ray films Contrast myelography is particularly useful for disclosing the outlines of any tumour within the spinal theca (Fig 21 15) or of any indentation of the thecal column resulting from the presence of an extrathecal tumour or other compressing lesion The procedure is open to the theoretical objection that some contrast media remain permanently within the theca and others are only very slowly absorbed To meet this objection air is sometimes employed as a contrast medium (air myelography) but in most English speaking countries the iodized oils are preferred because of their greater clarity



FIG 21 15 MYELOGRAMS SHOWING THE CONTRAST MEDIUM IN CONTACT WITH (A) THE LOWER POLE OF AN INTRADURAL SPINAL TUMOUR, AND (B) THE UPPER POLE OF THE TUMOUR.

Electroencephalography This method of investigation is really a specialty in itself and its use in neurosurgical diagnosis is somewhat limited. Its chief value is in disclosing the presence and site of foci epileptic discharges so that it is an essential aid in the surgery of epilepsy With rapidly growing tumours, cerebral abscesses and other destructive lesions, slow wave activity is often seen However the localization of such activity is frequently not sufficiently accurate for the placing of a craniotomy and radiological procedures provide greater accuracy in this respect.

Operative Procedures

The Principles of Craniotomy Once a tumour or other operable lesion has been located by clinical methods supplemented by the ancillary investigations which have just been considered the surgeon is in a position to proceed to a craniotomy The type of craniotomy of course, varies according to the site and expected nature of the lesion, and according to whether an excision, inspection of the lesion or merely a decompression is anticipated Modifications of technique are required for subtentorial tumours. The following description applies to the exposure of a tumour of a cerebral hemisphere.

Pre-operative Preparation. Nowadays most craniotomies are carried out under intratracheal anæsthesia (oxygen, nitrous oxide, ether or Trilene), and the pre-operative medication is much as for operations in other regions. Premedication consists usually of a suitable barbiturate drug by mouth and atropine gr 1/100 intramuscularly is given an hour before.

The clipping of the hair and the shaving of the scalp are left until the morning of operation so that if the scalp be scratched or scored, the scratches will not have time to become infected. Often it is kinder to leave the shaving until the patient is anæsthetized It is not necessary to shave the whole scalp, only the area of operation. A saline intravenous drip can be set up so that blood transfusion can be facilitated if required during operation As a precautionary measure one or two bottles of blood are suitably matched to the patient s blood group and held in readiness in the blood bank

The Operation The type of craniotomy generally used to expose the cerebral hemisphere is known as the osteoplastic flap exposure. Three main variations are employed to expose the frontal lateral and occipital regions respectively (Fig. 21 16) The principle in each variation is the same, namely

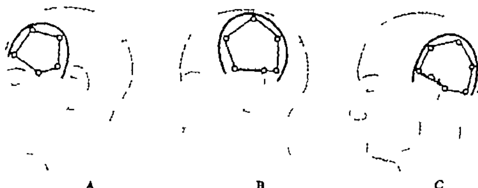


FIG. 21 16. THE INCISION AND OSTEOPLASTIC FLAP FOR CRANIOTOMY IN (A) THE FRONTAL AREA, (B) THE PARIETAL AREA AND (C) THE OCCIPITAL AREA.

to turn down the various coverings in three separate layers (*a*) *the scalp* (*b*) *the skull and pericranium pedicled on the temporal muscle, and* (*c*) *the dura.*

The scalp incision is an inverted U-shape, so planned that it includes at least one major scalp artery in its base. For frontal flaps these are the frontal and supra-orbital branches of the ophthalmic artery for a lateral flap the superficial temporal artery and for a posterior flap the occipital artery The actual incision is made in sections so that blood loss is minimized The assistants press firmly on the scalp with their fingers along both sides of each section in turn, while the surgeon makes the incision through all layers of the scalp including the aponeurosis. The surgeon then picks up the aponeurosis with a succession of fine hæmostats, applied ½ inch (1 cm.) apart which evert the scalp and so control bleeding. Alternatively special scalp clips such as those designed by Raney can be used. After the scalp incision is completed the scalp flap is dissected off the pericranium and folded downwards. Any bleeding from the scalp not controlled by the hæmostats or clips is controlled by diathermy coagulation of the individual bleeding points

The bone flap is so designed that when elevated it will be pedicled on the

temporal muscle This means that for lateral craniotomies it is turned downwards, but for frontal or occipital craniotomies it is turned laterally The pericranium is incised along the margins of the proposed bone flap entering just into the temporal fascia below the superior temporal crest. The temporal fascia otherwise is undisturbed A series of drill holes each about ½ inch (1 cm.) diameter outlining the bone flap are made either by hand with a brace, perforator and burr or with a mechanical drill Then a guide is passed between the skull and dura from one burr hole to the next the guide carrying a Gigli's saw (Fig. 21 17) With this saw the skull is cut between the two burr holes, care being taken to bevel the cut outwards. When all the burr holes have been joined by cuts, the flap is elevated with levers and its base broken beneath the temporal muscle. This fractured base is then trimmed with rongeurs. Should a bony decompression be required as much bone as possible is removed from beneath the temporal muscle. Any

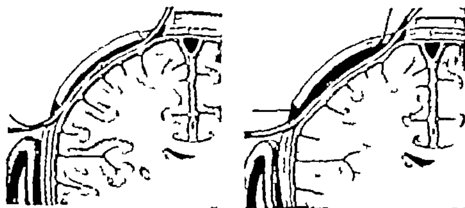


FIG. 21 17 METHOD OF INSERTING A GIGLI SAW BY MEANS OF A GUIDE, WHICH ALSO ACTS AS A PROTECTOR.

The skull is cut with the saw the underlying dura mater and brain are protected by the guide.

bleeding from the cut edge of the skull is controlled by bone wax pressed into the diploë.

The dura is now exposed and any bleeding from the branches of the middle meningeal artery is sealed with diathermy This is done by isolating the bleeding point with a sucker and then applying diathermy through fine pointed forceps. Small points of venous bleeding can be controlled in the same way Large sources of venous bleeding, as for instance from punctures of the superior longitudinal sinus, can be controlled temporarily by cotton wool packs, and permanently by "stamps" of hammered muscle of absorbable gelatin sponge, or of absorbable cellulose gauze The dura can then be opened as deemed most appropriate, generally by a U-shaped flap. If the brain is under considerable pressure, the ventricle must first be tapped with a needle and the pressure released before the dura can be safely opened. Bleeding from small vessels in the cut edge of the dura can be controlled by diathermy or by silver clips (*Fig.* 21 18)

Incisions in the brain substance can be made as required by one of several methods. Most cerebral arteries and veins run either over the surface

of the cortex or in the depth of sulci leaving the actual white matter comparatively avascular One method is to seal the surface vessels along the line of incision with diathermy and then cut the coagulated vessels with scissors The actual white matter can then be divided either with a blunt spatula or with a fine-bore metal suction tube which has the advantage of combining in one tool a dissecting instrument and a sucker

Any bleeding vessels in the depths of the incision can be located with the sucker and sealed with diathermy applied either *via* the sucker or the diathermy forceps. An older method is for the surface vessels and also the deeper vessels to be isolated with a sucker and then occluded with silver clips. Yet another method is for the surface vessels to be under-run with fine silk ligatures inserted on a ligature carrier and then tied on both sides of the proposed incision before being cut with scissors.

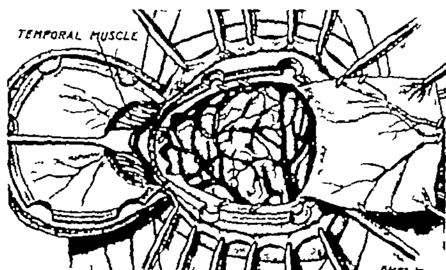


FIG. 21 18. OSTEOPLASTIC METHOD OF OPENING THE CRANIUM.

It will be noticed that the bone flap is wider above than below, thereby facilitating division of the base openings have been made by a small burr, and the base divided, the dura mater has been turned up and the meningeal vessels controlled with silver clips.

In closing the craniotomy the dura may be left open to provide a decompressive effect or it may be sutured with silk if the intracranial pressure is low The bone flap is then replaced, and if it has been correctly cut, it will sit firmly in position with no more fixation than a few interrupted stitches placed in the pericranium. Otherwise it can be fixed in position with wire Finally the scalp is sutured with two layers of interrupted silk stitches A deeper layer placed at intervals 1 cm. apart sutures the aponeurosis and remains permanently in situ. The superficial layer approximates the skin edges and is removed in a few days.

Some surgeons drain their craniotomies while others do not. In either case the surgeon on the first two post-operative days may have to insert a brain needle beneath the galea and aspirate any collection of fluid Healing of the scalp is usually rapid and if the general condition is favourable the patient can usually get up in a few days.

The Principles of Laminectomy The operation of laminectomy is required whenever the spinal cord has to be exposed as for removal of a spinal tumour or for a rhizotomy or cordotomy The pre-operative medication anæsthesia and skin preparation are similar to those employed for other major surgical operations. The patient is usually operated upon in the prone position but he may be placed on his side or sitting up Care is taken in positioning him that there is no compression of the abdomen for this leads to an engorgement of the extradural venous plexus and to venous bleeding

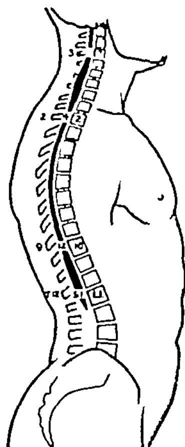


Fig 21 19 The Relation of the Spinal Cord to the Spinal Column in the Adult

Generally the spines and laminæ of three successive vertebræ are removed including those of the vertebra at the anticipated level of the lesion as well as those of the vertebræ above and below this level. If need be, however a more extensive laminectomy can be performed In plotting the level allowance must be made for the fact that the spinal cord is shorter than the spinal column, as is illustrated in Fig. 21 19

The operation commences with a vertical midline incision through skin and subcutaneous tissues over the tips of the spines of the vertebræ which are to be removed The erector spinæ and other posterior spinal muscles are then cut with a diathermy knife off the sides of the spines and the posterior aspects of the laminæ. When divided in this way there is little bleeding from the muscle, as happens, however when the muscle is stripped off the

bone with a chisel or raspatory A self retaining retractor is then inserted to retract the muscles. Next the spines are removed with large rongeurs. The laminae are then nibbled away in turn from below upwards with smaller rongeurs, while the remnants of the ligamenta flava are also removed. Any bleeding from the cut bony surfaces is controlled with bone wax. In this way the posterior aspect of the dural theca is exposed and any bleeding from the extrathecal vessels is controlled with diathermy applied through finely pointed forceps. Finally the dural theca is opened in the midline posteriorly exposing the spinal cord itself, still within its arachnoidal sheath As the theca is incised, it is held open by silk stay sutures brought out to the surface of the laminectomy wound (Fig. 25 8)

The further manipulations depend, of course, on the purpose of the operation, *e g* removal of a tumour section of the antero-lateral columns, or merely a decompressive laminectomy If need be the arachnoid is incised The cord itself should not be directly retracted or palpated. If it has to be retracted a slip of the ligamentum denticulatum on one side is cut off the theca, seized with a pair of mosquito forceps and used as a tractor to rotate the cord (Fig. 25.9)

In closing a laminectomy the dural thecal wound is sutured with inter rupted silk stitches. The muscle layers are then approximated with heavier silk stitches and finally the skin and subcutaneous tissues are sutured If the suturing is carefully done, through and through tension sutures embracing large portions of muscle are not desirable. The skin sutures are left in situ about ten days before removal.

Chapter 22

HEAD INJURIES

Introduction

As a result of road and other accidents, head injuries are to-day occurring with increasing frequency A knowledge of their mechanisms and management is therefore very important. In our museums and X ray departments it is the fractured skull which attracts attention but in reality it is the damage to the underlying brain which is generally of greater importance. Indeed, sometimes the brain may be severely damaged without there being a visible mark on the scalp or a fracture line in the skull. The converse is also true, for the scalp and skull may be injured without the patient having been concussed It is therefore convenient to consider the effects of head trauma in two main respects (*a*) Injuries to the coverings of the brain, *i.e* scalp skull, and meninges, and (*b*) Injuries to the brain itself

In this connection a subdivision of some importance is into (*a*) closed or blunt head injuries, and (*b*) open or penetrating injuries. The distinction between the two is that in the open injuries a track has been opened between the intracranial cavity and the exterior of the body by which infection can reach the brain. This track may be wide or it may be narrow A mere cut of the scalp or fracture of the skull does not constitute an open injury it is essential that the dura be torn as well Most injuries in civil life are of the closed type. But every now and then an injury which at first sight appears closed is in reality an open injury (*e g* a puncture wound of the skull or a fracture involving the paranasal sinuses) and it is important that such injuries be early recognized for what they are, steps being taken to prevent intracranial infection.

Injuries of the Brain Coverings

Injuries of the Scalp

Traumatic lesions of the scalp consist of abrasions, contusions, hæmatomas, lacerations, and avulsions. The management of *abrasions* and *contusions* follows the treatment of similar injuries of the skin in other parts of the body It is important, however that the damaged area be inspected for any minute puncture, such as might have been caused by a spike (Fig. 22 7) This will be discussed again later

Hæmatoma. Hæmatomas may form beneath the galea (fronto-occipital aponeurosis) or beneath the pericranium. *Subaponeurotic* (*subgaleal*) *hæmorrhage* is quite common, and tends to trek as a thin layer throughout the loose tissue beneath the aponeurosis A massive *subaponeurotic hæmatoma*, however is uncommon and takes the form of a large fluctuating swelling upon which the scalp appears to float, bogging down over the eyes or occiput. There is often an associated fracture of the underlying skull with tearing of the pericranium, the blood coming from the diploic vessels No

Depressed or Punctured Fractures. Although less frequent than fissured fractures these are more important surgically (Fig. 22 3) Invariably caused by direct violence they are often comminuted as well as depressed The inner table of the skull vault is generally more extensively fractured than the



Fig. 22 3 A Depressed Fracture of the Vault Seen from Without

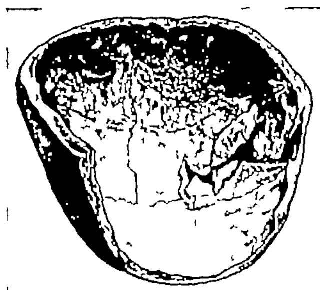


Fig. 22 4 A Depressed Fracture of the Vault Seen from Within.

outer table (Fig. 22 4). Simple depressed fractures may occur (Fig. 22 5) More frequently however they are open and especially when there has been penetration by a sharp object the underlying dura is often torn, and dirt hair and bone fragments are carried into the underlying brain Locally blood and perhaps even a little mashed brain tissue is seen escaping from the scalp wound Skiagrams will reveal the extent of damage (Fig. 22 6). From the clinical viewpoint a depressed fracture can occur without the patient

having lost consciousness for the actual indenting of the skull cushions the general concussive effect of the blow

In infants and young children a depressed fracture of greenstick type can occur (Fig. 22 5) These are more like an indentation in the wall of a table-tennis ball and when elevated with a curved instrument inserted through a burr hole will rebound back into position without a visible fracture line



Fig 22 5 A Simple Depressed Fracture of the Vault in a Child.

Treatment Most depressed fractures should be operated on, but the time of choice depends upon whether the fracture is open or not. Simple depressed fractures, even if there is no loss of consciousness or neurological signs should be elevated, for a permanently depressed area pressing upon the brain is apt to provoke epileptic attacks. However the operative reduction of a fracture can often be deferred for several days until the patient s general condition permits surgery The reduction, however should not be delayed longer than fourteen days or so otherwise bony union in the depressed position may take place and the fracture then becomes irreducible except by a major craniotomy The principle of elevating a depressed frac



Fig. 22 6. A Pond-shaped Depressed Fracture.
The same patient as illustrated in Figs. 22 7 and 22 8.

ture is to make a small scalp flap over it, and then place a burr hole in the intact skull bordering on the depressed area (Figs. 22 7 and 22 8) Through this burr hole the point of a curved periosteal elevator or similar instrument is inserted between the dura and the depressed fragments, which are then levered back into position.

An open depressed fracture should be operated upon within the first twenty-four hours under full antibiotic cover An intratracheal anæsthetic is desirable except with a small fracture in a co-operative patient, when local analgesia will suffice The scalp is widely shaved and chemically sterilized and the dirtied edges of the scalp wound are then débrided. The various bony fragments should be inspected. All loose bony fragments



FIG. 22 7 AN OPEN DEPRESSED FRACTURE PREPARED FOR OPERATION.

The small punctured wound over the centre of the fracture was first excised. The line of the scalp flap then reflected for proper exposure of the fracture is also shown.



FIG. 22 8 A DEPRESSED FRACTURE SHOWN AFTER REFLECTION OF SCALP AND PERICRANIUM.

A small burr hole has been made to the left side of the fractured area, and through this a periosteal elevator was inserted to raise the fragments.

driven into the brain should be removed together with all dirt and hair for such fragments are potential sources of later infection as well as epilepsy Any clots and mashed brain should be sucked out and any bleeding cortical vessels sealed with diathermy However it is not necessary to remove the large fragments which are still attached to pericranium unless they are obviously contaminated with dirt they should be merely levered into position. The edges of the dural tear should be sutured if possible or if not protected by bone, covered by a graft of temporal fascia or pericranium which is stitched into position. The scalp wound is then closed completely and this is possible in most compound fractures. If however there has been an extensive loss of scalp tissue, relieving incisions may be required The removal of all bony fragments as formerly practised is no longer required for under the cover of suitable antibiotic drugs most wounds treated as described above will heal by first intention and with a minimum of skull defect. Should infection supervene, its spread is limited by antibiotics and any sequestrated bony fragments can be removed later In the case of a punctured fracture by a gunshot wound, it is not necessary to remove the bullet, for the bullet itself is rendered sterile by its own heat at the time of wounding. From the surgical viewpoint this is fortunate because the

missile often penetrates deeply and inaccessibly into the brain leaving the dirt and bony fragments in the superficial part of the track

Finally if after healing there is a sizeable skull defect the question of its operative repair after an interval of some months should be considered A variety of materials have been employed to fill in the defect ranging from autogenous bone grafts to plates of some inert metal like tantalum The simplest repair material however is the use of one of the quick setting and self-sterilizing acrylic resins which are now readily available and can be fashioned at the time of re-operation to fit the individual defect.

Injuries of the Brain

In most cases of head injury the disturbances in the underlying brain are of greater importance than any injury sustained by the scalp or skull Indeed in many severe head injuries of closed type extensive and serious damage may be sustained by the brain, yet the skull may remain intact or be only slightly fractured

Accompaniments of Closed Head Injury *Concussion* The most striking feature of all but the mildest closed head injuries is the instantaneous loss of consciousness which is often described as concussion or stunning. This loss of consciousness varies in severity and duration from a mild momentary dazing and confusion of thought to profound insensibility with prolonged loss of consciousness. Fortunately even after severe injuries, most patients recover and as recovery ensues the following stages of lessening unconsciousness can be discerned

(1) The stage of *coma* or deep insensibility in which all responses except perhaps such elemental responses as the corneal reflex are lost.

(2) The stage of *semicoma* or stupor in which the patient will respond to painful or disagreeable stimuli

(3) The stage of *confusion* in which the patient will respond to the spoken voice In the deeper stages of confusion he may be very drowsy responding either by movements or by a few words more of annoyance than of co-operation. In the lighter stages of confusion he may seem alert and readily enter into conversation but he is disorientated in time and place and lacks clear and consecutive memory

(4) The stage of *traumatic intellectual impairment* in which the patient has regained his orientation and memory but not yet regained his full intellectual powers.

The dividing line between the state of " unconsciousness and the state of " consciousness " is a hard one to define. To most laymen it lies between the stages of deep and light confusion More practical, however are distinctions based on memory and orientation. On recovery from the stages of confusion a patient will exhibit an amnesia for his accident which is divisible into two parts. All patients who have been concussed lack memory of the receipt of the actual blow Many also exhibit a *retrograde amnesia* covering the events immediately preceding the accident. The duration of the retrograde amnesia, however is seldom more than a few minutes. More important is the *post traumatic amnesia* which covers the stages of coma, semi-coma and confusion and which terminates with the return of clear orientation and of continuous memory In estimating the post traumatic amnesia, transient islands of recollection during the period of confusion

should be disregarded. The duration of the post traumatic amnesia may range from a few seconds or minutes to several weeks or months and is useful as a yardstick for comparing the severity of closed head injuries in different patients It is not so useful in patients with a depressed or punctured skull fracture for in some of these the underlying brain may have been penetrated and locally damaged without the patient having lost consciousness.

Pathological Changes in Closed Head Injuries. It is common knowledge that occasionally a patient may die from the effects of concussion without fracturing the skull and even without visible macroscopic changes being found in the brain at post mortem. Yet in practice, in the more severe head injuries, actual structural damage to the brain also occurs To resolve this paradox it is customary to subdivide the pathological changes in the brain into two types (*a*) commotio cerebri and (*b*) the ordinary structural changes of contusion laceration, hæmorrhage and œdema

Commotio Cerebri. This term is appropriately vague but is often employed to denote the interruption of cerebral function which is the essential basis of the clinical state of concussion and which is not due to any visible lesion. Its precise nature is unknown, although some of its characteristics and properties are appreciated, one of the most important being that it is reversible. The experimental work of Denny Brown and Ritchie Russell has shown that it is usually produced by sudden alterations in the velocity of the head above a certain minimum acceleration The head must be free to move, and the alterations of velocity may be either positive as from a blow or negative as when a moving head hits a stationary object. Mere crushing or indentation of the head without acceleration or deceleration can produce extensive fracturing and even distortion of the skull without loss of consciousness. In the past, several theories of commotio cerebri have been put forward but none are convincing. The attractive and popular theory of Trotter that it is due to momentary cerebral anæmia consequent upon the brain being squeezed like a sponge at the moment of impact, is no longer tenable. Physicists have pointed out that at the velocities involved in concussion, the fluid contents of the skull react like solid bodies. Other theories, such as the traumatic interruption of the synapses, are without proof Present day neurophysiological ideas are converging on the view that, what ever the nature of the lesion responsible for concussion, its site is focused in the brain stem.

Contusion of the Brain. Laceration, hæmorrhage and œdema are found in varying degrees in most severe head injuries. Contusions and lacerations are presumably sustained at the moment of accident, while hæmorrhage and œdema are secondary phenomena. These macroscopic abnormalities tend to occur at certain sites, such as in the brain beneath the point of impact of the blow at the point of contre-coup and particularly at the temporal poles and inferior frontal regions in relation to the sphenoidal ridges. This predilection of sites is explicable by the rotational stresses which arise in most injuries, for the head, through its attachment via the neck, swings on the body through the three planes of space and not merely accelerates or decelerates in a straight line These rotational stresses lead to focal lesions. A simple illustration is afforded by taking a glass of water and rotating it. While the glass itself moves, the mass of water tends to stay behind and shearing strains become particularly marked at the junction of the water with the glass. By analogy in head injury similar strains occur between the

skull and the softer brain lying inside it The skull however is not a perfect sphere and, where a partition like the sphenoidal ridges projects into the brain, shearing strains and consequent damage are particularly likely The amount of blood present in the cerebrospinal fluid during the first three or four days after the accident is a rough guide to the severity of the various structural changes

Although loss of consciousness in a severe head injury is primarily due to commotio cerebri these macroscopic lesions aggravate and prolong it. The hæmorrhage may be subarachnoid intracerebral sub- or extra-dural Hæmorrhage and reactionary œdema lead to cerebral swelling which in its turn produces tentorial pressure coning, with perhaps the onset of brain-stem hæmorrhage In the severest injuries these reactionary changes may lead to early death In other instances the various structural changes may lead not only to prolonged unconsciousness but also to focal neurological signs and even when the patient regains consciousness, some of these signs may prove to be persistent or even permanent

Management of Closed Head Injuries. The plan of management is divisible into two stages, (*a*) the acute initial stage which is generally contemporaneous with the stage of unconsciousness, and (*b*) the stage of con valescence. Although the management during both stages is mainly one of medical and nursing supervision the surgeon must be conversant with the various problems of head injury and must be constantly on the watch in case some complication arises which requires active surgical intervention.

The Acute Stage The therapeutic problem here is, will the patient live or die and what steps can be taken to assist his recovery? The steps are mostly those of skilled nursing attention. Although most patients will recover without any need for surgical intervention, between 1 and 2 per cent. of cases will develop an extradural hæmorrhage that will require prompt surgical treatment.

From the practical viewpoint *two-thirds of patients who have been concussed will have regained consciousness by the time they reach hospital* Yet the occasional patient will be harbouring a developing extradural hæmorrhage and so all patients with head injury particularly those who have been concussed no matter how mildly should be watched carefully for the first twenty-four to forty-eight hours. In deciding whether a patient, who denies head injury has really been concussed, the examiner should first test his orientation in time and place. A disorientated patient is probably still in the stage of light confusion and his statements should be discounted. Indeed he may subsequently have amnesia covering his interrogation. If the patient is orientated he should be tested for his recollection of the injury If he appears to have an amnesia for the actual blow he was probably concussed. All such patients should be admitted to hospital for at least twenty four hours careful observation. The enquiries to be made are suitable variants of those listed in the next few paragraphs.

About a third of patients with head injuries are still unconscious on reaching hospital. The medical officer should examine the patient forthwith before he is transferred from stretcher to bed, recording the following observations

(1) Particulars of the accident as obtained from eye witnesses, police or ambulance drivers

(2) The depth of unconsciousness as judged by the patient s responses to painful stimuli, to shouts or to conversation.

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(1) Particulars of the accident as obtained from eye witnesses, police or ambulance drivers.

(2) The depth of unconsciousness as judged by the patient's responses to painful stimuli, to shouts or to conversation.

(3) Examination of the head for signs of external injury as well as bleeding from the nose and ears.

(4) Gross injuries in other parts of the body Associated fractures of the limb bones, and chest or abdominal injuries are present in about a third of cases

(5) Neurological signs, paying particular attention to any differences in response on the two sides of the body Among the points looked for are (*a*) Relative size of the pupils and their response to light (*b*) The motor responses, both voluntary and to stimulation, of the two arms and two legs (*c*) State of biceps, triceps, knee and ankle reflexes and also the plantar responses. The precise state of these reflexes is not as important as any differences between the two sides of the body

(6) Pulse and respiration rates, axillary or rectal temperatures and blood pressure level.

From these observations a tentative assessment of the severity of the patient's injuries can be made. Any fractures of long bones should be promptly immobilized by simple splintage, and any scalp wounds covered with simple antiseptic dressings leaving definitive treatment until later The management is mainly one of skilled nursing. Once in bed in the ward the patient is placed in the horizontal position, with his head on one side in case he vomits. Unless his other injuries prevent it, he should be turned from side to side every two or three hours to relieve pressure points and to prevent hypostatic pulmonary congestion. Any accumulation of mucus, pulmonary secretions or vomitus should speedily be removed by suction applied through a rubber catheter Generally the unconscious patient will be incontinent of urine, but if he does not pass urine within twelve to eighteen hours he should be catheterized. Also if he becomes restless, his bladder state should be investigated, because, in a confused patient, a full bladder is a common cause of restlessness.

Throughout this period of unconsciousness the nursing staff should be instructed to keep careful records of the patient's progress, so that any improvement or deterioration can quickly be noted. The records should be half hourly for the first four hours, and thereafter hourly They include (*a*) A note as to the depth of unconsciousness as judged by responses to painful stimuli (*e g* pinching), to shouted commands and to conversation (*b*) A comparison of the movements of the limbs of the two sides of the body (*c*) The pulse, respiration and temperature Two-hourly blood pressure levels can also be added (*d*) The relative sizes of the patient's pupils.

Signs that a patient is improving include a steady lightening of unconsciousness together with a return towards normality of the various examinations. Signs that a patient is deteriorating include first an increasing depth of unconsciousness and second, deviations from normal of the other records. A small minority of patients will deteriorate and die in spite of all efforts. Signs of grave omen besides deepening coma, are a rapid increase in respiration and pulse rates (without hyperpyrexia) occurring within a few hours of injury These are the result of œdema and hæmorrhage both intracerebral and subarachnoid, supervening on contusion and laceration. Lumbar puncture is often useful in distinguishing such cases from extradural hæmorrhage, for in cerebral laceration the lumbar cerebrospinal fluid is usually bloodstained whereas in extradural hæmorrhage it is either clear

or only faintly pink The recognition and treatment of extradural hæmorrhage will be considered later

It is important that repeated body temperature recordings be obtained in the early stages after head injury because occasionally deepening coma and rapid deterioration is due to *hyperpyrexia* the result of a disturbance of heat regulation secondary to a hypothalamic lesion The normal sweating responses are in abeyance and the pulse and respirations are always increased As a patient s temperature rises, his clothing should be stripped and even fanning begun. If his rectal temperature exceeds 104 5° F more energetic methods of cooling are required Tepid sponging is usually not adequate and the bared body should be covered with lumps of ice. Rectal temperatures should be taken every ten minutes to chart progress and even with such vigorous measures it may take ten to twenty minutes to lower the rectal temperature by 1 F The ice packing should be terminated as soon as the rectal temperature falls below 103 degrees. It is sometimes remarkable how a patient who is comatose and unresponsive at a temperature of 106° F will start responding to the spoken voice when his temperature falls below 103° F

Certain other points in the nursing management of an unconscious patient call for comment. A certain amount of restlessness does no harm, provided the patient does not disturb limb fractures or fatigue himself A full bladder should be excluded and light restraint, such as bed boards, provided to prevent falling out of bed. Irritability in which the patient curls up avoiding the light and resents any attention is quite common and is sometimes described as cerebral irritation If restlessness is marked, sedatives may be required, of which intramuscular paraldehyde 5 ml. repeated four hourly as required is one of the safest.

The fluid and nutritional requirements must be remembered particularly when unconsciousness is prolonged. If the patient will not swallow a fine bore stomach tube should be introduced into the stomach through the nostril and left in situ Feeds of up to 200 ml of various nutritional fluids fortified with vitamins can then be readily given every two hours, ensuring a fluid intake of about 2 to 2½ litres each twenty four hours. A few surgeons actively dehydrate their patients even to the extent of giving twice daily magnesium sulphate enemas, on the grounds that such therapy counteracts widespread cerebral œdema and lessens the chances of post-contusional headaches. However no valid statistical evidence in support of such claims yet appears to be forthcoming and most neuropathologists deny the existence of widespread, as opposed to focal, cerebral œdema.

Difficulty with respiration is often encountered in a drowsy or comatose patient because of the depression of the cough reflex. Secretions tend to accumulate in the pharynx and bronchial passages, and unless these are cleared the patient will develop pulmonary collapse or bronchopneumonia All such patients should be given an antibiotic cover and the nasal and pharyngeal airways cleared as frequently as necessary by suction. If such measures prove inadequate, tracheostomy should be performed.

Recently in some neurosurgical centres a few patients with profound coma and signs of decerebration have been treated by hypothermia, usually produced by administration of the "lytic cocktail" (based on chlorpromazine) plus surface cooling with a fan It is the general experience that as the body temperature falls to 32° C. (88° F) or lower the muscular

rigidity from the decerebration relapses. The decerebration is generally due to brain stem hemorrhages, and patients who are so severely disturbed seldom make satisfactory recoveries. There is no proof as yet that hypothermia materially benefits such patients.

The value of lumbar puncture during the acute stage of head injury is one concerning which varied opinions are held It is probably advisable that every unconscious patient should be lumbar punctured at least once to ascertain the pressure and state of the cerebrospinal fluid This should be done towards the end of the first day or earlier if the patient s condition appears to be deteriorating. The amount of blood present is an approximate guide to the severity of the macroscopical structural changes in the brain. Even in severe head injuries the pressure levels are seldom raised, but if they are elevated from 5–20 ml. of cerebrospinal fluid can be released to bring the pressure down to normal levels, and the procedure can be repeated next day Certainly the release of small amounts of blood-stained cerebrospinal fluid especially when under pressure, has a soothing effect as regards restlessness and headache After about four days the cerebrospinal fluid tends to clear spontaneously

The question of obtaining skiagrams of the skull is another problem which arises. Generally the difficulties in obtaining good quality projections in unconscious and unco-operative patients outweigh their merits, and these investigations should be deferred to the early convalescent period Exceptions to this rule are of course afforded by the actual or suspected presence of depressed or punctured fractures, and the steady deterioration of a patient's condition suggesting the possibility of a middle meningeal hemorrhage.

Fortunately most unconscious patients will regain consciousness within a few hours or days when the convalescent stage is ushered in with a new set of problems. In the minority of patients who remain unconscious for several days, nursing care is of paramount importance. In a patient who is awake but confused, measures designed to stimulate his physical activity such as physiotherapy sitting out of bed or even immersion in a warm bath have to be considered.

The Convalescent Stage Once the patient becomes alert and orientated the therapeutic problem changes from one concerned with his survival to one concerned with how he can be assisted to make the fullest possible recovery compatible with any permanent residual disability It is necessary at this stage to make a systematic re-assessment paying particular attention to the following points

(1) The severity of the injuries, as judged by such criteria as (*a*) the duration of the post traumatic amnesia, (*b*) the recorded duration and depth of unconsciousness, and (*c*) the amount of blood in the cerebrospinal fluid during the first three days after injury

(2) Any evidence of persisting damage to scalp skull or brain. This involves full physical and neurological examination and good skiagrams of the skull. This latter examination has come to be regarded by the legal profession as a proof of thoroughness of investigation, but in actual practice linear fractures of the vault without displacement can be disregarded from the viewpoint of further treatment or prognosis, unless they involve the paranasal sinuses.

(3) The patient s previous health, work and intellectual records, including the family history By and large a previously healthy person who comes of

robust stock will make a quicker and more complete recovery than one who shows neurotic traits

No hard-and fast rules can be given regarding convalescence but the emphasis is placed on steadily graduated physical exercises commencing early but avoiding fatigue and mental anxiety Most patients recovering from concussion show no permanent neurological sequelæ The old dictum that all patients who have been concussed should be confined to bed for three weeks to avoid post-concussional headaches is not appropriate for most patients need only a short period of bed rest Indeed a patient who has been concussed for only a few hours, can generally be got out of bed on the third or fourth day for ten minutes By this time most patients are free of headache Thereafter the daily periods are steadily lengthened and the patient encouraged to walk around the ward If headaches or other symptoms appear progress is slowed At the end of ten days the average patient can be allowed home and instructed to take increasing amounts of outdoor exercise If circumstances permit a short holiday will complete the convalescence The emphasis throughout is on restoring a patient to good physical health leaving mental activities to a later date

The average times taken for patients to return to full work after head injuries of varying severity were given by Guttman as follows (*a*) Slight injuries if post traumatic amnesia (P T A) is less than one hour return to work within four to five weeks (*b*) Moderate injuries P T A of twenty four hours return to work within five to six weeks (*c*) Severe injuries P T A of from one to seven days return to work within nine weeks.

Complications of Head Injuries

Certain complications such as scalp injuries, depressed fractures basal fractures skull defects, hyperpyrexia and restlessness have already been considered Among other complications are (*a*) Local neurological lesions (*b*) Prolonged confusion with confabulation (*c*) Extradural hæmorrhage (*d*) Subdural hæmorrhage in adults (*e*) Subdural hæmatoma in infants (*f*) Fractures involving paranasal sinuses (*g*) Post traumatic epilepsy (*h*) Post-concussional headaches.

Local Neurological Signs. A wide variety of neurological signs indicating focal damage may become apparent in the acute stages and persist into the convalescent stage Some of these are serious, others are of lesser significance Among the more common which we shall list and evaluate are hemiplegia and aphasia bilateral anosmia defects of vision oculomotor disturbances, facial paralysis and unilateral deafness with its associated disturbances of equilibrium

Hemiplegia or Monoplegia This is generally partial and usually indicates a contusion of the pre-Rolandic region It generally clears within a few weeks Associated *aphasia* occurring by itself is uncommon, and usually results from focal contusion or subcortical hæmorrhage around the Sylvian region of the dominant hemisphere Usually this sign will also disappear spontaneously but if it persists and is marked for more than two weeks an exploratory craniotomy designed to remove the subcortical clots may hasten recovery

The remaining neurological signs usually indicate cranial nerve lesions or lesions of the sense organs. *Bilateral anosmia* supervenes in about 5 per

cent. of head injuries, and occurs in two types of case. The first type includes injuries with fractures of the anterior cranial fossa which damage the olfactory nerves or bulbs The second type follows occipital injuries, often with a fracture of the squamous occipital bone, when the olfactory filaments are torn by shearing. Both types often have a lengthy post traumatic amnesia, and may show other focal neurological signs. The loss of smell is usually permanent.

The *optic nerve* and even *optic chiasm* are sometimes involved through fractures of the anterior cranial fossa which traverse an optic foramen. The involvement manifests itself by a defect in the field of vision of one or both eyes, and occasionally even by complete unilateral blindness Such defects are usually permanent.

Fractures of the petrous temporal bone may lead to facial nerve and labyrinthine lesions, and bleeding from the ear through a ruptured tympanum at the time of injury is a common accompaniment. The *facial palsy* may be present from the time of injury or more commonly it is delayed in its onset for a few days. In either event recovery will ensue after an interval, but it is generally incomplete as after a Bell's palsy More subtle and more important, however are lesions involving the *labyrinth* These are associated with some degree of unilateral deafness and usually also with tinnitus. Particularly troublesome is a subjective disturbance of balance with an accompanying loss of confidence in walking in crowded places. The caloric responses in the affected ear are impaired or lost. This disturbance of balance is similar to that seen after labyrinthectomy or eighth nerve section for Ménière's syndrome, and although the lesion is permanent, ultimate recovery of confidence in gait is usual after three to six months. In the meantime, however the patient (unless the nature of his disability is recognized) may be regarded as neurotic.

Prolonged Confusion and Confabulation. Post-traumatic psychosis, which is an alternative term occasionally occurs after a severe head injury A patient may remain in a confused and disorientated state for weeks or months. Physically he may seem fit and alert, but in his conversation he tends to live in the past. Frequently such patients will confabulate and may make delusional statements (Korsakoff's psychosis) Yet the ultimate prognosis for many of these patients is good, and after some months they will make a complete recovery A patient in such a state presents several therapeutic problems. Expert neurological advice should be sought, and bilateral exploratory burr holes (with perhaps ventriculography) should be made to exclude a subdural hæmatoma or hygroma. Once any surgically remediable lesion has been excluded, the problem becomes one of graduated exercises and occupational therapy given over a period of several months. Many such patients gravitate to mental hospitals since the faculties for management there are usually more appropriate than in general hospitals.

Extradural Hæmorrhage. This complication occurs in less than 2 per cent. of closed head injuries. The bleeding may be arterial or venous in origin (Fig. 22 9) The usual mechanism is for a fracture to cross one of the branches of the middle meningeal artery generally at the antero-inferior angle of the parietal bone, but bleeding may occur from the artery without perceptible fracture. Occasionally the bleeding comes from the superior longitudinal venous sinus, the exact mechanism being obscure One must remember however that venous obstruction in the neck or thorax, even

though temporary may lead to very high pressures within the intracranial sinuses

Symptoms The chief symptom is increasing drowsiness progressing to coma and this usually manifests itself within the first six hours of injury or at the most two or three days In the classical picture the patient is initially concussed for several minutes, and then regains consciousness (*lucid interval*) only to pass again into unconsciousness within an hour or two Variants, however occur and the patient may be unconscious from the time of injury without exhibiting a lucid interval or rarely he may not even have been concussed As drowsiness deepens and coma supervenes the pupil of the eye on the ipsilateral side dilates (due to a partial third nerve palsy) and a

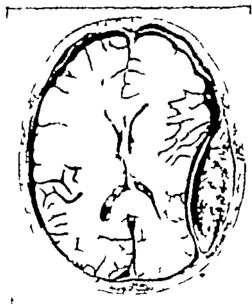


FIG 22 9 EXTRADURAL HÆMORRHAGE (*Royal College of Surgeons Museum.*)

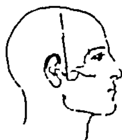


FIG. 22 10 INCISION FOR EXPOSING THE MIDDLE MENINGEAL ARTERY



FIG. 22 11 THE AREA OF BONE REMOVED IN CASES OF MIDDLE MENINGEAL HÆMORRHAGE.

hemiparesis may appear on either the opposite side (due to pressure on the motor cortex) or on the same side (false localizing sign due to displacement of midbrain against the tentorium) Such signs therefore are later in onset.

The chief differential diagnosis in such cases is from severe cerebral laceration and contusion. Lumbar puncture is often helpful, for in cerebral lacerations the cerebrospinal fluid is heavily blood-stained, while in extra dural hæmorrhage the cerebrospinal fluid may be clear or only slightly tinged with blood Indeed the lumbar puncture pressure may be low Skiagrams are also valuable in showing a fracture of one parietal bone

Treatment If there is any doubt, operation should be undertaken promptly in all cases of progressive drowsiness. It is wiser to make a negative exploration than to leave the coroner's pathologist to demonstrate a removable clot. Intratracheal anæsthesia is desirable, for the patient is often restless and difficult to control. Both sides of the head should be shaved and prepared for operation, for the correct interpretation of the

localizing signs is often difficult and if the wrong side should be opened, operation on the second side can quickly follow

The scalp incision employed is a vertical one in the temporal fossa (Fig. 22 10). The temporal muscle is divided in the same line and its fibres separated. At this stage the bluish colour of the extradural clot can often be seen showing through the thinned squamous temporal bone and a fracture line with clot exuding is common A burr hole is made and the skull defect enlarged to 3 to 4 cm. diameter with rongeurs. If the diagnosis is correct the extradural clot is usually immediately exposed and can be removed by suction. Often the bleeding point in the middle meningeal artery then shows up and can be sealed with diathermy As the clot is removed, the depressed dura usually rises up steadily against the skull. This is a good omen and the muscle and scalp incisions can be closed forthwith. If the dura remains markedly depressed, progress should be more cautious for uncinate impaction is present. *The head of the table is lowered lumbar puncture performed,* and 40 to 60 ml. of normal saline run into the theca under hydrostatic pressure. This drastic measure will often lead to disimpaction. Alternatively the dura is opened and after elevating the temporal lobe from the middle cranial fossa, the tentorium is divided outwards from the tentorial opening.

Subdural Hæmorrhage in Adults. This complication is not frequent, but *its precise incidence is uncertain for its clinical manifestations are generally*

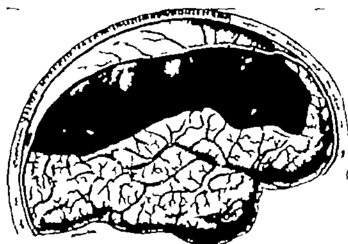


FIG. 22 12 A LARGE SUBDURAL HÆMATOMA.

delayed at least a week and usually several weeks and by that time the actual injury may have been forgotten. The initial injury often seems trivial and the usual mechanism would appear to be one of shearing strains causing rupture of one of the cerebral veins that traverse the subdural space. A certain amount of blood collects in the subdural space and clots. At this stage the patient *usually does not lose consciousness although he may* appear dazed. (Occasionally however a solid subdural clot causes symptoms.) The clot may cover part or most of the convexity of one or both cerebral hemispheres (Figs. 22 12 and 22 13). Thereafter in the next few weeks two distinct pathological processes occur concurrently The first is that granulation tissue develops over the inner and outer surfaces of the clot in relation to the arachnoid and *dural coverings, leading to the formation of lining membranes.*

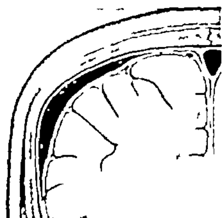


FIG 22 13 A CHRONIC SUBDURAL HÆMATOMA.

This pathological process represents an attempt at spontaneous absorption of the hæmatoma. The second process is that towards the end of the first week the clot tends to liquefy Simultaneously with this liquefaction water is sucked into the hæmatoma presumably by osmosis from the cerebrospinal fluid in the subarachnoid space This second process therefore leads to dilution of the hæmatoma with an increase in its bulk. This increase may for a while be in excess of absorption and lead to symptoms of delayed raised intracranial pressure. Non-traumatic subdural hæmatomas also occasionally form as a sequel to a leaking intracranial aneurysm.

Symptoms The common symptom is fluctuating drowsiness associated



FIG. 22 14 ARTERIOGRAM SHOWING DEPRESSION OF THE BRAIN AWAY FROM THE SKULL BY A SMALL SUBDURAL HÆMATOMA.

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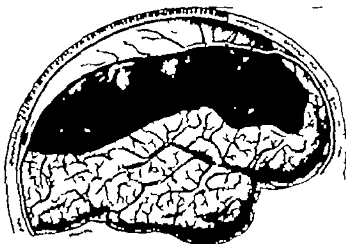


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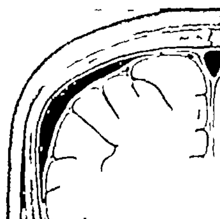


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Symptoms The common symptom is fluctuating drowsiness associated



FIG. 22 14 ARTERIOGRAM SHOWING DEPRESSION OF THE BRAIN AWAY FROM THE SKULL BY A SMALL SUBDURAL HÆMATOMA.

with confusion and this manifests itself over days or weeks. Neurological examination often discloses papillœdema but little in the way of localizing neurological signs (apart from quadrigeminal plate signs) The lumbar puncture pressure may be normal or slightly raised and the cerebrospinal fluid either clear or very faintly xanthochromic. *Many patients present as cases of cerebral tumour in a comparatively silent area for by the time symptoms appear the head injury has been forgotten.* The correct diagnosis in such cases can be established by cerebral arteriography (Fig. 22 14) or by air encephalography *If however the head injury is remembered and the true diagnosis suspected, one can proceed to operation without such aids.*

Treatment Operation consists in making one or more burr holes over the suspected hemisphere, including occipital ones for ventriculography should the pre-operative diagnosis prove wrong. Local analgesia is usually adequate. In positive cases when the dura is opened, a thin bluish membrane is uncovered and when this is punctured thin black fluid blood escapes. This fluid will not clot on standing. The cortex is then seen displaced from the dura (Fig. 22 13) *After as much blood has run away as possible, a catheter is inserted into the subdural space which is irrigated with saline to dilute any remnants of hæmatoma* Usually this is all that is necessary for the cortex begins to come up against the dura as the hæmatoma escapes. *The scalp incisions are then sutured and the patient is returned to bed.* Improvement is usually rapid but it is wise to nurse the patient with the head low for several days to prevent reaccumulation. If reaccumulation occurs and symptoms return, or if at the time of operation the lining membranes are unduly tough *a major craniotomy with excision of the hæmatoma is required.*

Sometimes the fluid in the subdural space is so diluted with cerebrospinal fluid that it appears brownish Such cases are often referred to as subdural hygromas and in these the symptoms may be less marked.

Subdural Hæmatoma in Infants. Subdural hæmatoma occurs in the newborn, the mechanism being comparable to that occurring in adults. The precipitating factor is the distortion of the skull during parturition Symptoms, however do not usually appear until the child is two or three months old The child seems slow to develop does not take feeds well may exhibit convulsions and has a large head with a big anterior fontanelle. The diagnosis is confirmed by tapping each subdural space with an aspirating needle inserted at the lateral angle of the anterior fontanelle. If fluid blood is encountered (and this should not clot), 10 ml. should be removed. Aspiration thereafter can be repeated daily for a few days If the infant does not improve or fluid continues to accumulate, craniotomy should be undertaken and the hæmatoma with its surrounding membranes dissected out. One reason why craniotomy is often necessary is that the inner membrane often hinders the natural expansion and growth of the brain Consequently until it is removed the child will not develop properly

Fractures Involving the Paranasal Sinuses. These fractures occur in 5 to 10 per cent. of all closed head injuries and are important because in a quarter to a third of such cases intracranial infection supervenes. Hence the importance of securing good skiagrams routinely in all patients who have sustained a head injury (Fig. 22 15).

Most of these fractures follow blows over the forehead but a few follow fractures of the middle third of the facial skeleton. The risk of infection



FIG. 22 15 A FISSURED FRACTURE OF THE VAULT TRAVERSING THE POSTERIOR WALL OF THE LEFT FRONTAL SINUS.
The left frontal sinus is opaque from a contained blood clot.

stems from the fact that the dura is often torn in relation to the fracture line thereby opening up a pathway by which organisms (particularly the pneumococcus) may reach the intracranial cavity causing meningitis or an abscess. Furthermore air may enter the intracranial cavity causing a frontal aerocele (Fig. 22 16) or a spontaneous ventriculography Thirdly cerebrospinal fluid may leak into the nose causing cerebrospinal rhinorrhœa Infection however can occur without there having been either frontal aerocele or cerebrospinal rhinorrhœa.



FIG 22 16. A FRONTAL AEROCELE.

Two reasons why the appearance of complications may be delayed for months or years are first that the fracture line into the sinus may be plugged for a while with brain tissue and second that the dural tear may be nipped in the fracture line with its serous surfaces inverted so that adequate fibrous union cannot occur across the gap. If infection supervenes, the treatment initially is that of the inflammatory process. Generally this is a pneumococcal meningitis, and indeed all cases of pneumococcal meningitis should have their skulls X-rayed to ensure that an unsuspected or forgotten fracture line is not a causal factor Sometimes, however a cerebral abscess occurs instead No definitive operation to prevent recurrence can be undertaken until the infection is overcome

Treatment The correct treatment of these fractures is to operate in advance of infection. It is not necessary to operate in all cases in which a fracture line crosses the frontal or ethmoidal sinuses, and those cases in which the fracture line is a mere chink without complications can be left alone. But the following indications for operation can be given (*a*) A history at any stage after injury of cerebrospinal rhinorrhœa, (*b*) A history of meningitis or aerocele (*c*) Any case in which careful X ray studies show a fracture line more than 2 mm wide crossing a paranasal sinus, particularly when there is displacement of bony fragments.

The operation itself can be performed at any stage, but the time of election is in the second week following a head injury so as not to prolong unduly the total convalescence. A frontal craniotomy is performed on the affected side, or on both sides if necessary the dura is opened and one or both frontal lobes are elevated off the anterior cranial fossa to expose the fracture lines. A sheet of fascia (from either the temporal region or the thigh) is then laid over the damaged area and secured in position. The operative risks are negligible, and the prognosis against recurrence of infection are excellent. In a patient seen in the acute stage, in whom there is an associated fracture of the mid facial skeleton a plastic surgeon should first reduce the facial fracture during the first week under antibiotic cover leaving the operative repair of the dural defect until about two weeks later

Post-traumatic Epilepsy Epileptic attacks develop in from 2 to 3 per cent. of closed head injuries, and in a higher proportion (given variously as from 5 to 30 per cent.) after penetrating injuries The fits usually appear in from two days to two years after injury and generally can be controlled by phenobarbitone or similar anticonvulsant drugs. In the few cases in which they prove disabling and intractable, the patient should be referred to a neurosurgical centre for possible excision of an underlying meningocortical scar

Post-concussional Headache. Most patients lose all headache within a day or so of injury and in only 5 to 10 per cent. of patients do troublesome headaches persist. The causes of such headaches are various and often obscure. In a small minority of cases they may be associated with papillœdema, the underlying cause being either a subdural effusion or a thrombosis of the superior longitudinal venous sinus. In the majority of cases anxiety factors seem largely responsible, and there are no abnormal physical signs

All patients with persistent headaches should be investigated carefully attention being paid to psychological factors. It is wise always to perform a lumbar puncture and if there is a suspicion of a subdural effusion or of papillœdema, exploration of the subdural space followed if negative by

ventriculography should be considered The majority of patients (especially those without signs) are not benefited by these measures, and in them treatment should be directed towards helping the patient to readjust himself to his changed circumstances Psychological factors should be sought and if possible corrected It is often wise to explain to the patient that symptoms like headache, dizziness and impaired concentration are frequently slow to disappear and that consequently he may have to modify his activities for many months. If he cannot manage his previous work, he may have to take up something simpler and easier or start with shorter hours of work gradually building up to the required number Few patients are permanently and organically disabled but many more are made neurotic by injudicious handling.

Chapter 23

DISEASES OF THE SKULL AND BRAIN

Introduction

The scalp and skull are subject to the same affections as are other skin surfaces and other portions of the skeleton. Thus the scalp may be the site of infections, injuries and cutaneous tumours (*e g* sebaceous cysts, epitheliomas and rodent ulcers). Similarly the skull may be the site of a wide range of infections (granulomas and osteomyelitis) generalized skeletal abnormalities (osteitis fibrosa, osteitis deformans, etc.), injuries and tumours (osteoma, sarcoma, metastatic) In this section those conditions whose presence in the head is merely coincidental are omitted and only those conditions which have an interest peculiar to the head are described.

Developmental Abnormalities

Cranium Bifidum. A range of abnormalities comparable to those seen in spina bifida is not uncommon in the skull of the newborn. A *meningocele* (Fig. 23 1) is a protrusion of the brain membranes containing cerebrospinal



FIG. 23 1 A MENINGOCELE OF THE FRONTAL REGION.

fluid It may occur at various sites, particularly the anterior and posterior fontanelles and the base of the skull. It forms a soft, rounded fluctuating *swelling, attached to the skull by a base of greater or lesser size* It is covered by skin which may be thick, leathery or thinned and translucent. The vessels present in the skin are often dilated as in a naevus. The swelling increases in size on any respiratory effort, such as coughing and crying and it may be partially reducible, thus allowing the margins of the opening in the cranium to be palpated A *meningo-encephalocele* is a similar type of protrusion containing brain tissue derived from the underlying hemisphere *Cranioschisis* is a term used to designate the more extreme varieties, in which the nervous tissue is exposed with little or no sac formation.

Prognosis This varies with the complexity of the abnormality and with the presence of other associated abnormalities. In cases of simple meningocele it may be good for the sac can be excised without damage to the underlying brain In other cases idiocy microcephaly or hydrocephalus may be present The surgeon must therefore assess the general status of his patient in collaboration with his paediatric colleagues before deciding on operation

Treatment The excision of a meningocele is normally a simple matter, but a cranioschisis is usually not remediable Operation is carried out only if there are prospects of the child s subsequent development being reasonably normal

Craniostenosis. This results from premature closure of one or more of the sutures of the cranial vault and usually commences in early infancy Depending upon its extent and severity it results in (*a*) skull deformity



FIG. 23 2. A CHILD WITH OXYCEPHALY



FIG. 23 3 SKIAGRAPHIC APPEARANCE OF OXYCEPHALY

(*b*) secondary microcephaly with backwardness and (*c*) visual loss. The condition can be largely corrected by an operation aimed at freeing the closed suture lines, but it is important that the condition be recognized and operated on within the first six months of life. This is because the rate of growth and development of the skull and brain are particularly rapid during that period

The nomenclature of the different types of craniostenosis is based upon the characteristics of the skull deformity which, in its turn, depends upon the extent and placement of the fused suture lines. In *oxycephaly* or *turricephaly* (Fig. 23 2) premature stenosis occurs at all suture lines forcing the skull to grow upwards at the anterior fontanelle and leading to the characteristic tower-shaped deformity This is usually accompanied by a small skull with raised intracranial pressure markings (Fig. 23 3), bilateral exophthalmos and associated secondary optic atrophy *Scaphocephaly* or boat-shaped skull results from premature closing of the sagittal suture with continued growth at the coronal and lambdoid sutures. The severity of deformity and other signs are usually less marked *Plagiocephaly* or flat skull, results from premature closing of the coronal suture resulting in a flat and

high forehead with increased growth at the sagittal and lambdoid sutures.

The treatment of these cases is by operation designed to open up the closed suture line either with a Gigli's saw or by cutting a groove with rongeurs. A film of some inert substance such as polythene is then placed permanently in the cleft between the bone edges to prevent the skull from reuniting at this point and thus allowing for expansion

Congenital and Infantile Hemiplegia. The differentiation between congenital hemiplegia (resulting from a lesion present at birth) and infantile hemiplegia (resulting from a lesion acquired after birth) is often a difficult and arbitrary one. Even with a congenital lesion detectable signs of a hemiparesis are usually not apparent until the infant is many months old, for the limb movements which a young baby makes, are not dependent upon the cerebral cortex. The degree of weakness and disability with a congenital or infantile hemiplegia is usually less marked than with a similar condition in adult life. The affected arm and leg are somewhat smaller than the sound limbs and usually possess good power at the proximal joints such as hip, knee, shoulder and elbow Movements at the toes and ankles are usually weak with a tendency to talipes equinus. Mobility of the fingers may vary from complete absence to useful prehensile movements Sensory loss is even more difficult to determine, for touch and pain are rarely impaired A homonymous hemianopia may complete the clinical picture, but as the child has become adapted to this it may require ingenuity on the examiner's part to demonstrate it. The causes of congenital hemiplegia are various and include maldevelopment of the hemisphere (Fig. 21 11) birth trauma, porencephaly and Sturge Weber's syndrome. The last condition is particularly striking, for it includes a bluish capillary naevus over part of the trigeminal area of one side of the face (Fig. 23 4), and a characteristic radiographic abnormality due to hemiatrophy and capillary angiomatosis of the cortex with deposition of calcium within the deeper layers of the cortex



Fig. 23.4 Sturge Weber's Syndrome showing the Unilateral Distribution of the Capi Cutaneous Angiomato Territory of the Tri Nerve.



Fig. 23 5 Skull cification in the in Sturge We Characteristic Cal Cerebral Hemiatrophy ie.

(Fig. 23 5) True infantile hemiplegia is rare and its causes include encephalitis and obscure vascular diseases

The surgical interest in congenital hemiplegia is two-fold First the surgeon may be asked to perform a tenotomy of the tendo Achillis or an arthrodesis of the foot to assist in walking Second the hemiplegia may be associated with epilepsy which in its turn is associated with behavioural disorders and backwardness. If the epilepsy proves intractable to drug therapy its relief by surgery may be considered It is surprising how often an extensive removal of the damaged portion of the brain even to the extent of complete hemispherectomy improves the behaviour and intellect stops the fits and yet does not worsen the hemiparesis.

Hydrocephalus. Hydrocephalus is a term used in several contexts loosely it denotes any enlargement of the ventricular system be it the result of tumour or other obstructive lesion It is also sometimes employed in the term "otitic hydrocephalus" to denote a state of pseudo-tumour (without ventricular enlargement) seen as a complication of middle ear disease Generally however it is used specifically to describe the condition of undue and usually progressive enlargement of the head which is seen in infants and young children. This enlargement usually results from some obstruction, either congenital or acquired to the cerebrospinal fluid pathways, arising at a time when the normal sutures are still widely open so that the head is readily able to enlarge.

The circumference of a child's head steadily advances with increasing age, and the following table gives the approximate normal rate of progress

Average normal circumference of head

Birth	13 inches (32 5 cm)
1 month	14 inches (35 cm)
6 months	17 inches (42 5 cm.)
1 year	18 inches (45 cm)
4 years	20 inches (50 cm.)
12 years	21 inches (52 5 cm)
Normal variation	= ± 1 inch (2 5 cm.)

In the typical hydrocephalic infant the rate of increase is more rapid than this, and leads to excessive and usually progressive enlargement of the head with tense bulging fontanelles If the process is not checked, the head becomes too heavy for the child to raise, the eyeballs become depressed and staring the mental development is impaired and the body wastes (Fig. 23 6).

Ætiology The causes of infantile hydrocephalus are many some being congenital and others acquired. Among the congenital causes are atresia or stenosis of the aqueduct of Sylvius, imperforate septa in the roof of the fourth ventricle, and maldevelopment of the base of the skull such as platybasia. Among the acquired abnormalities are blockage of the exit foramina of the fourth ventricle or of the basal cisterns as a result of an attack of infantile meningitis, which at the time may not have been recognized. A few arise from tumours blocking the cerebrospinal fluid pathways.

The management of hydrocephalus requires nice judgment, for often in its early stages the process may right itself spontaneously resulting in "arrested hydrocephalus" and the child subsequently progresses normally although with an enlarged head In the first instance therefore the clinician

high forehead with increased growth at the sagittal and lambdoid sutures.

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FIG 23 4 STURGE WEBER'S SYNDROME SHOWING THE UNILATERAL DISTRIBUTION OF THE CAPILLARY CUTANEOUS ANGIOMATOSIS IN THE TERRITORY OF THE TRIGEMINAL NERVE.



FIG. 23 5. SKULL SHOWING CHARACTERISTIC CALCIFICATION IN THE SHRUNKEN CEREBRAL HEMISPHERE IN STURGE WEBER'S SYNDROME.

(Fig. 23 5) True infantile hemiplegia is rare and its causes include encephalitis and obscure vascular diseases.

The surgical interest in congenital hemiplegia is two-fold First the surgeon may be asked to perform a tenotomy of the tendo Achillis or an arthrodesis of the foot to assist in walking. Second the hemiplegia may be associated with epilepsy which in its turn is associated with behavioural disorders and backwardness If the epilepsy proves intractable to drug therapy its relief by surgery may be considered It is surprising how often an extensive removal of the damaged portion of the brain even to the extent of complete hemispherectomy improves the behaviour and intellect, stops the fits and yet does not worsen the hemiparesis

Hydrocephalus. Hydrocephalus is a term used in several contexts loosely it denotes any enlargement of the ventricular system be it the result of tumour or other obstructive lesion. It is also sometimes employed in the term "otitic hydrocephalus to denote a state of pseudo-tumour (without ventricular enlargement) seen as a complication of middle ear disease Generally however it is used specifically to describe the condition of undue and usually progressive enlargement of the head which is seen in infants and young children This enlargement usually results from some obstruction either congenital or acquired to the cerebrospinal fluid pathways, arising at a time when the normal sutures are still widely open so that the head is readily able to enlarge

The circumference of a child's head steadily advances with increasing age, and the following table gives the approximate normal rate of progress

Average normal circumference of head

Birth	13 inches (32 5 cm)
1 month	14 inches (35 cm)
6 months	17 inches (42 5 cm)
1 year	18 inches (45 cm.)
4 years	20 inches (50 cm)
12 years	21 inches (52 5 cm.)
Normal variation	= ± 1 inch (2 5 cm)

In the typical hydrocephalic infant the rate of increase is more rapid than this, and leads to excessive and usually progressive enlargement of the head with tense bulging fontanelles. If the process is not checked, the head becomes too heavy for the child to raise, the eyeballs become depressed and staring the mental development is impaired, and the body wastes (Fig. 23 6)

Ætiology The causes of infantile hydrocephalus are many some being congenital and others acquired Among the congenital causes are atresia or stenosis of the aqueduct of Sylvius, imperforate septa in the roof of the fourth ventricle, and maldevelopment of the base of the skull such as platybasia Among the acquired abnormalities are blockage of the exit foramina of the fourth ventricle or of the basal cisterns as a result of an attack of infantile meningitis, which at the time may not have been recog nized A few arise from tumours blocking the cerebrospinal fluid pathways.

The management of hydrocephalus requires nice judgment, for often in its early stages the process may right itself spontaneously resulting in "arrested hydrocephalus" and the child subsequently progresses normally although with an enlarged head. In the first instance therefore the clinician

should secure measurements of the child's head at intervals of three to four weeks, and only decide upon surgical intervention if the rate of enlargement of the head is definitely excessive

Varieties A useful classification from the point of view of surgical treatment is into (*a*) internal hydrocephalus and (*b*) communicating hydrocephalus. In the former condition the obstruction lies between the third ventricle and the spinal theca, *e.g* the aqueduct of Sylvius or roof of the fourth ventricle. In the latter condition it is in the basal cisterns, while the cerebrospinal fluid of the ventricles communicates freely with the spinal cerebrospinal fluid. The distinction can be made by injecting an inert dye



FIG. 23 6. ADVANCED HYDROCEPHALUS.
The greatly enlarged cranium, the overhanging eyebrows, the staring eyes, the wasted features and the attenuated body constitute a typical picture.

like phenolsulphonphthalein (1 ml. of 0·6 per cent. solution) into the lumbar theca and seeing whether the dye is present in appreciable quantities in the ventricular cerebrospinal fluid as determined by ventricular tap ten minutes later More precise information, however is gained by ventriculography Further investigation not only enables the distinction between internal and communicating hydrocephalus to be made, but also demonstrates the exact site and approximate nature of the obstructing lesion.

Treatment It is wrong to operate upon an advanced hydrocephalic, for the operation may merely result in perpetuating the life of an imbecile. In weighing up the pros and cons of treatment therefore, the mental state of the child will be considered (and this is often surprisingly preserved) as well as the state of the cerebral cortex. If the cerebral cortex and white matter surrounding the lateral ventricle (as demonstrated by ventriculography) is more than 2 cm. thick, a good result can be anticipated from operation If less than 1 cm. thick the outlook for useful recovery is poor

A whole range of operative procedures has been employed in hydrocephalus, indicating that none is really completely successful If the case is one of internal hydrocephalus, the obstruction can be by passed by either a third ventriculostomy (opening of the third ventricle into the cisterna

chiasmaticus by division of the lamina terminalis) or a Torkildsen's ventriculocisternostomy (placing of a polythene tube between the lateral ventricle and the cisterna magna) The results of such operations are often satisfactory In communicating hydrocephalus probably the best results follow diathermy destruction of the choroid plexus (Putnam's or Scarff's operation) This is done by means of a ventriculoscope inserted into the ventricle through a burr hole The mortality of operative removal of the choroid plexus is, however prohibitive

In recent years a spate of shunt operations has been tried the principle being to lead a polythene tube from either the spinal theca or the lateral ventricles to some cavity such as the ureter peritoneal or pleural cavity mastoid antrum, etc. Many of these operations produce striking relief of intracranial pressure in the early postoperative stages, but the later results tend to be disappointing The shunts into the peritoneum or pleura cease to function, while shunts into the ureter and mastoid cavity are liable to be followed by ascending infections

Vascular Lesions

Caroticocavernous Fistula or Pulsating Exophthalmos. The cavernous sinus with the internal carotid artery running through it is unique in the body in such a relationship of a major arterial vessel to a venous one. It is therefore perhaps not surprising that a fistula between the two sometimes develops, and that when it does do so it leads to striking clinical features.

Ætiology Two types of caroticocavernous fistulæ can be recognized, *vi*z. traumatic and spontaneous. The traumatic fistulæ are commoner and occur mainly in adult males. As a result of a severe head injury a fracture line crossing the base of the skull involves the carotid artery and leads either to direct rupture of the artery into the cavernous sinus or to the formation of a traumatic aneurysm which secondarily bursts into the sinus. The spontaneous form is less common, occurs mainly in middle-aged females and is



FIG. 23 7 A PATIENT WITH PULSATING EXOPHTHALMOS DUE TO CAROTICO-CAVERNOUS FISTULA.
Note the distended veins around the left orbit.



FIG. 23 8 CAROTID ARTERIOGRAM IN CAROTICOCAVERNOUS FISTULA.
Note that the blood-flow through the internal carotid artery is discharging into the cavernous sinus, and thence anteriorly into the orbital veins and posteriorly into the basal cerebral vein and straight sinus.

generally due to rupture of an aneurysm of the internal carotid artery where it lies within the sinus.

Symptoms Prominent among the clinical features of caroticocavernous fistula are a bruit and pulsating exophthalmos (Figs. 23 7 and 8) The bruit is loud systolic in timing, heard over most of the head, but particularly over the eye and often accompanied by a thrill. *It diminishes or even disappears when the carotid artery on that side is compressed digitally in the neck.* In cases of spontaneous fistula, it is usually the initial symptom and the patient can often recall the precise time at which it appeared. Once the bruit appears, pulsating exophthalmos usually becomes apparent within a few hours or days. The exophthalmos can be unilateral or bilateral. If unilateral it is usually present on the same side as the fistula, but several cases of contralateral exophthalmos have been reported. The pulsation is of course synchronous with the pulse Other clinical features include chemosis of the conjunctiva and engorgement of the veins of the eyelids and conjunctiva. *In traumatic cases there is often blindness and signs of other cranial nerve* lesions secondary to a fracture of the base of the skull

A further symptom is epistaxis. Occasionally in post-traumatic cases this may be catastrophic, and nose-bleeds of the order of a pint or more within ten minutes have been reported Such massive bleeding is the result of blood leaking more or less directly from the artery into the nasopharynx through a fracture line. It usually occurs shortly after the injury More often the nose bleeds are slight and intermittent, and are due to bleeding from engorged nasal veins. This tendency to epistaxis is the factor which largely governs the natural life history of untreated cases of caroticocavernous fistula. *In most patients the condition, after a marked degree of pulsating* exophthalmos has developed, becomes stationary and the patient continues free of nose-bleeds. Occasionally a spontaneous cure occurs. Cases with massive epistaxis, however are a serious problem, for in them death can occur from exsanguination. Cases with repeated minor nose-bleeds should also be regarded with suspicion for more serious nose-bleeds may develop with the passage of time.

Treatment Operative treatment is indicated when there are severe nose-bleeds, and when the patient is distressed by the bruit or the exophthalmos. The generally accepted treatment is by ligation of the affected internal carotid artery *in the neck. This treatment, however* is not without its risks, and in some cases symptoms of hemiplegia may develop due to inadequacy of the circulation to the ipsilateral hemisphere. For after the internal carotid artery has been occluded in the neck, the circulation of blood to the ipsilateral hemisphere may be further impaired by reflux of blood from the circle of Willis down the upper part of the internal carotid artery to the fistula

The routine performance of bilateral carotid arteriography in all cases will assist in preventing this complication. *In most cases of caroticocavernous* fistula arteriography of the ipsilateral carotid artery in the neck will show the contrast medium passing up the internal carotid artery and then shunting completely into the cavernous sinus (Fig. 23 9). Arteriography of the contralateral carotid artery however will show that the blood supply to both cerebral hemispheres is through the anterior and middle cerebral arteries, indicating a free flow of blood to the ipsilateral hemisphere *via* the collateral circulation through the circle of Willis. If this is the state of affairs, the surgeon should concentrate on preventing any possible reflux of blood from

the circle of Willis to the fistula. He should then perform an intracranial clipping or ligation of the internal carotid artery above the fistula, but below the circle of Willis, before he proceeds to internal carotid ligation in the neck

Spontaneous Cerebral Hæmorrhage In recent years considerable progress has been made with surgical treatment of spontaneous intracranial hæmorrhage particularly that due to cerebral aneurysms and arteriovenous malformations (cirsoid angiomas) An intracranial aneurysm is typically a sac like projection, ranging in size from 2 mm. to 2 cm., which occurs in the angle of branching of a major cerebral artery Generally the aneurysm is single, but in from 15 to 20 per cent. of cases, multiple aneurysms are present. Most aneurysms are found in close relation to the anterior part of the circle of Willis and are supplied from one or other carotid artery In 5 to 10 per cent. of cases, however the aneurysms lie on the vertebral-basilar arterial system. In the past these aneurysms have often been described as of congenital origin but in fact they are acquired lesions resulting from the interplay of two main factors. The first factor is a congenital deficiency of the medial coat of the arterial wall, which sometimes occurs at the point of bifurcation of an artery The second is the occurrence of atheroma which weakens the intima at the point of deficiency of the media. An aneurysm may cause neurological symptoms by local pressure. More often, however it leads to sudden and unheralded intracranial hæmorrhage, and particularly so in the age period between fifty and seventy years.

Ætiology Arteriovenous malformations are briefly mentioned in the section on brain tumours. They are not neoplasms, however but are congenital arteriovenous fistulæ (Figs. 24 17 and 18) Such, however is the confusion of terminology that in the literature they are referred to by a variety of names among which may be listed cirsoid angiomas, arteriovenous angiomas, arteriovenous fistulæ and arteriovenous aneurysms. They occur most often over the convexity of one cerebral hemisphere, but may occur within the substance of the brain or in the posterior fossa. They range greatly in size, from a simple communication a few millimetres across to a tangled mass of arteries and veins up to 10 cm. in diameter While the larger malformations usually manifest themselves by epilepsy the smaller generally do so by intracranial hæmorrhage. The incidence of such hæmorrhage reaches its peak in the second and third decades of life

Both these lesions thus lead to spontaneous cerebral hæmorrhage and there are various varieties of this as well as various causes. The varieties of spontaneous cerebral hæmorrhage usually described are intracerebral subarachnoid and intraventricular but often these varieties occur conjointly in the same patient. These varieties must be distinguished from extradural and subdural hæmorrhages which are generally of traumatic origin. Primary intracerebral hæmorrhage is by far the most frequent variety and its common cause is rupture of an atheromatous cerebral artery Death in such cases occurs early and rapidly In a minority of cases of primary intracerebral hæmorrhage the patient survives the initial bleed In a proportion of these an intracranial aneurysm on a buried vessel such as the middle cerebral artery or the anterior communicating artery is the responsible lesion.

Primary subarachnoid hæmorrhage and primary intraventricular hæmorrhage both produce the same clinical picture, and are due to similar lesions. Primary intraventricular hæmorrhage is infrequent, while primary subarachnoid hæmorrhage, although more common, is not as frequent as intracerebral

hæmorrhage. In subarachnoid hæmorrhage bleeding intracranial aneurysms are responsible for about 80 per cent arteriovenous malformations are responsible for 10 per cent., while a miscellany of lesions are responsible for the remainder

Treatment In the past, spontaneous subarachnoid hæmorrhage has customarily been treated by prolonged bed rest, but the hospital mortality in such circumstances usually ranges between 50 and 60 per cent., while half of the survivors exhibit some neurological disability One reason for this high mortality is the frequency with which recurrent hæmorrhages occur These recurrences record their peak incidence between the second and fourth weeks after the initial hæmorrhage, but may occur at any stage up to years afterwards. Further if the patients who survive and leave hospital after approximately six weeks are traced, 20 per cent. will be found to have died of recurrent hæmorrhage.



FIG. 23 9 CAROTID ARTERIOGRAM SHOWING ANEURYSM (ARROWED) ON THE POSTERIOR ASPECT OF THE INTERNAL CAROTID ARTERY

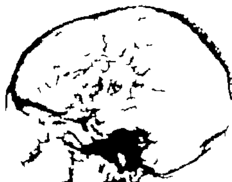


FIG. 23 10 CAROTID ARTERIOGRAM SHOWING ANEURYSM OF THE ANTERIOR COMMUNICATING ARTERY

For these reasons, surgeons have interested themselves in recent years in the surgical treatment of this condition. Operative intervention in intra cranial aneurysms with mortality rates as low as 6 per cent. in large series of cases have been reported, a distinct improvement on the results of conservative treatment. The first step in the surgical diagnosis of these cases is carotid and vertebral arteriography (Figs. 23 9 and 10). This is probably best delayed for a few days after the initial hæmorrhage, but should be carried out before the end of the first week The investigation should be performed bilaterally as multiple aneurysms are not infrequent. If carotid arteriography proves negative, vertebral arteriography should follow In about 70 per cent. an intracranial aneurysm can be demonstrated generally on the carotid arterial tree. Arteriovenous malformations are usually shown in about 10 per cent of these. The remaining 20 per cent. will include intracerebral hæmatomas without demonstrable cause and an occasional malignant glioma. In about 10 per cent. the arteriographic findings do not disclose any abnormality

Once the nature and site of the lesion has been shown, its definitive operative treatment can be planned. For aneurysms of the intracranial

internal carotid artery the sheet anchor of treatment is usually carotid ligation (common carotid ligation followed later in some cases by internal carotid ligation) When there is no adequate collateral circulation, such aneurysms can generally be exposed by a craniotomy as can aneurysms of the middle cerebral artery carotid bifurcation and anterior communicating artery Once the aneurysm is exposed a choice of several procedures is open. If its neck is narrow it may be occluded with a clip or ligated with silk Sometimes the main feeding artery can be occluded More generally however the walls of the aneurysm can be reinforced by external packing with hammered muscle Lowering of the blood pressure by means of hypotensive drugs is a useful adjunct during these operations

The ideal treatment of an arteriovenous malformation is its excision which is generally practicable when the lesion is situated over the convexity of the cerebral hemisphere When this method is not practicable as when the malformation is deep-seated the principal feeding arteries may be clipped.

Intracranial Infections

Pyogenic intracranial infections may affect the brain, the ventricular and leptomeningeal spaces, the subdural and extradural spaces the intra cranial blood vessels and the cranium itself The infective process may remain localized to any one of these structures, or it may spread depending upon the virulence of the causal organisms and the resistance of the host. Nowa days most infections can be controlled or confined by the adequate use of appropriate antibiotic drugs and in many instances no other treatment is necessary In some cases, however the need for surgical intervention still persists and in this section therefore the value and scope of surgery as an adjunct to antibiotic therapy will be presented.

A pyogenic infection generally reaches the intracranial structures by one of three main routes (*a*) by penetrating head injuries (*b*) by spread from an infected paranasal air sinus, notably the frontal sinus, or the middle ear and mastoid antrum or (*c*) by the blood stream from a distant focus such as a bronchiectatic cavity in the lung, a carbuncle or any focus likely to produce bacteræmia. Thanks to better operative treatment of compound head injuries and to improvements in otolaryngological surgery infections caused by the first two of these routes have become less frequent, while infections resulting from blood borne spread are relatively commoner In treating any intracranial pyogenic infection the source must always be located and dealt with to prevent recurrence

Acute Pyogenic Meningitis. Acute pyogenic meningitis may result from infection reaching the leptomeningeal spaces through a variety of routes, the principal organisms being the pneumococcus, *Streptococcus pyogenes Staphylococcus aureus* meningococcus and *Hæmophilus influenzæ* Among the routes of surgical importance may be listed (*a*) Penetrating injuries and cerebrospinal rhinorrhœa (*b*) Secondary spread from infection in the paranasal sinuses or the middle ear (*c*) Rupture or leakage of a brain abscess into the ventricles or subarachnoid spaces and (*d*) Blood-borne infection secondary to septic foci elsewhere, particularly in the thoracic cavity

The typical clinical features of meningitis are described in all text-books of medicine. The infection can occur at any age The onset is abrupt with fever severe headache, neck rigidity vomiting and photophobia. The diagnosis is confirmed by examining the cerebrospinal fluid obtained by

lumbar puncture The cerebrospinal fluid usually contains several hundred polymorphonuclear cells per c.mm. and the responsible organism, although sometimes identifiable on direct smear examination, is usually not isolated except by culture From the practical viewpoint the exact identity of the organism is of less importance than a knowledge of its relative susceptibilities to the various antibiotics, for the antibiotic agent of choice in treatment is that to which the organism is most susceptible

Treatment The treatment of pyogenic meningitis is first the exhibition of the appropriate antibiotic drug in adequate dosage followed at the appropriate time by treatment of the causal focus of infection or causal lesion. As the exact identification of the organism and the determination of its sensitivity to antibiotics may take twenty four to forty-eight hours, it is usually wise, pending this information, to start treatment by administering penicillin solution both intramuscularly and intrathecally The intrathecal dosage commonly employed is 20,000 units once daily and should not exceed 30 000 units, for cases of vascular thrombosis of the cord have been reported with higher dosages. Streptomycin can also be combined with penicillin in dosages of 2 g. per day by intramuscular injection, and 0 1 g. per day by intrathecal injection. If the organism, when identified, proves to be resistant to penicillin, or the clinical response has not been prompt, some other antibiotic such as tetracycline or chloramphenicol (as indicated by the sensitivity tests) should be substituted, being given by mouth or intramuscularly Few of the common antibiotic agents other than penicillin, streptomycin and chloramphenicol can be given intrathecally If however the appropriate antibiotic is used orally and parenterally in adequate amounts, intrathecal injections are usually unnecessary

The timing of the treatment of the causal focus of infection is a matter of judgment, depending largely on the simplicity or complexity of the measures required. Thus, if there is a known cerebral abscess, the sooner this is relieved by simple aspiration the better likewise a myringotomy can be performed in the acute stage of an otitis media, or an acutely infected frontal sinus can be drained externally If the causal lesion requires a major operation as for instance in a case of chronically infected mastoid antrum or cerebrospinal rhinorrhœa it is usually wiser to wait until the acute leptomeningeal infection has subsided before embarking on a radical mastoidectomy or on the repair of a cerebrospinal fluid fistula.

Brain Abscess. A brain abscess is situated usually within the substance of either a cerebral or cerebellar hemisphere, and a distinction should be made from those abscesses which occur in the subdural and extradural spaces. The clinical picture depends not only on the situation of the abscess within the brain, but also on its age and degree of encapsulation. In the early stages of a brain abscess there is really an area of acute suppurative encephalitis with as yet only an early response on the part of the host's tissues to limit the spread of infection. This state, sometimes known as an acute brain abscess, is comparable to acute cellulitis in other parts of the body However after the spread of infection has become limited by phagocytosis and antibody reaction, a collagenous and glial fibrous capsule is formed around the suppurative zone leading to the state often described as a *chronic encapsulated abscess* Such collagenous encapsulation usually takes three weeks or more to develop, and is weakest in its deepest part towards the ventricle, so that if at any stage the body defences break

down, secondary abscesses may form deep in the white matter or rupture into the ventricle

Ætiology The ætiology of brain abscess is similar to that of pyogenic meningitis From the ætiological viewpoint brain abscesses can be divided into three main groups

(1) Secondary to local infections of the head either by direct spread or by infected venous thrombosis (*a*) Infections of the mastoid antrum and middle ear both acute and chronic (*b*) Infections of the frontal or ethmoidal

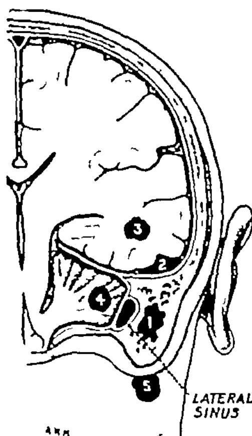


FIG. 23 11 DIAGRAM REPRESENTING THE SPREAD OF COMPLICATIONS OF SUPPURATIVE DISEASE OF THE MIDDLE EAR.

1 Dilated and infected mastoid antrum 2, subcranial (subdural) abscess from infection through the roof of middle ear or mastoid 3 abscess in temporal lobe 4 cerebellar abscess 5 Bezold's abscess through perforation of tip of mastoid process.

air sinuses, both acute and chronic or (*c*) Infections of the face and scalp (cellulitis and erysipelas), skull (osteomyelitis) or dental infections.

(2) Secondary to metastatic blood borne infections (*a*) Pulmonary *e g* lung abscess, bronchiectasis and pleural empyema (*b*) Distant systemic infections, *e g* boils, carbuncles and endocarditis or (*c*) Congenital heart disease.

(3) Secondary to penetrating head injuries (*a*) Open fractures of the skull (*b*) Frontal and ethmoidal sinus fractures or (*c*) Gunshot wounds.

The incidence and variety of brain abscesses nowadays is changing from that seen before the antibiotic era. Formerly the common types of abscess

were the otogenic or the rhinogenic ones. Although brain abscess can complicate acute otitis media or acute frontal sinusitis, it usually supervenes upon long-standing chronic infections in these regions. From the middle ear and mastoid antrum infection may spread either by continuity or more usually by infected connecting venous channels to either the temporal lobe or to the cerebellum (Fig. 23 11) There the abscess develops in the white matter close to the cortex. In a few instances an extradural abscess may intervene between the infected cavity and the cerebral abscess, but this is not common, the infection generally passing through to the brain without a continuous macroscopic line of communication. In an occasional case a lateral sinus thrombosis may also occur while sometimes infection also passes through the mastoid up into the tissues of the neck leading to Bezold's mastoiditis Similarly in rhinogenic abscesses, spread usually occurs into the inferior portion of the frontal lobe without the interposition of an extra dural abscess. Distant spread, however also occasionally occurs to other parts of the brain, such as the parietal lobe, presumably through infected venous thrombophlebitis. Reference to these conditions is also made in the chapters dealing with the ear and paranasal sinuses. Chronic infections of the paranasal sinuses, however are no longer left unoperated upon as they formerly were, and thanks to this and the universal use of antibiotics during acute exacerbations of sinus infections, cerebral abscesses of otogenic or rhinogenic origin are becoming uncommon.

Metastatic abscesses of pulmonary origin or from other blood-stream infections, which are often multiple, were formerly almost invariably fatal. Now their virulence is attenuated by antibiotics and they are seen in increasing numbers in the chronic stage. One group of particular interest is those seen in congenital disease of the heart, for the primary source of blood stream infection may never be apparent. Indeed it appears that about 5 per cent. of children with congenital heart disease ultimately develop a cerebral abscess. These various metastatic abscesses may affect any part of the brain, but particularly those areas of the frontal and parietal lobes supplied by the middle cerebral artery

The bacteria responsible for brain abscesses differ greatly from case to case In abscesses secondary to septicaemia a pure infection by one organism such as the pneumococcus, *Streptococcus pyogenes* or the *Staphylococcus aureus* is sometimes seen. In most cases, however the infection is a mixed one comprising both aerobic and anaerobic organisms, and including cocci, bacilli and spirochaetes.

Symptoms The clinical picture of the early invasive stage of intracranial infection is characterized by severe headache, vomiting, slowing of the pulse and drowsiness passing into coma epileptic attacks occasionally occur There are also localizing neurological signs depending on the part of the brain which is involved, ... a left temporal ... one usually finds aphasia, right lo... kness, and ... monymous hemianopia. Unless py... of an intracranial abscess is afebri... may or ... There is thus seldom any ... that ... complication has supervened ... of ... d the clinical picture is that ... lesion. Occasionally however the ... y pass ... then mimics a neoplasm

Diagnosis The clue to diagnosis is recognition of the significance of the symptoms in the presence of a source of intracranial infection The lumbar cerebrospinal fluid is rarely normal, and usually contains up to 100 mg per 100 ml of protein and an increase of white cells of from 10 to 200 per c.mm. both lymphocytes and polymorphs. Lumbar puncture is thus often a valuable diagnostic aid distinguishing the condition from pyogenic meningitis (where the cell count is usually more than 1 000) and pointing the need for further investigations. Among these further tests some authorities would consider carotid arteriography for supratentorial lesions and ventriculography for deep-seated hemisphere and infratentorial abscesses By either of these radiological techniques it is usually possible to determine the presence of an intracerebral abscess and its precise site.

Treatment This resolves itself first into the treatment of the abscess,

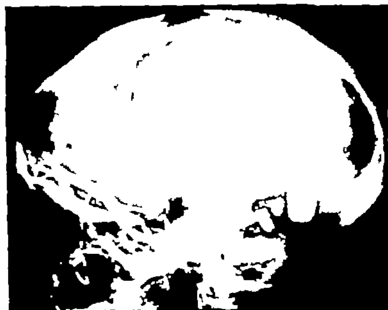


FIG. 23 12. TWO ABSCESS CAVITIES IN THE CEREBELLUM, EACH CONTAINING THOROTRAST THE SMALLER IS CONTRACTING AND UNDERGOING CICATRIZATION.

and second the eradication of the source of infection. Now that antibiotics can do so much to limit and control the invasive stage of encephalitis, the treatment of cerebral abscess has been simplified. In general it consists of the administration of the appropriate antibiotic (most often penicillin) in adequate amounts, either orally or parenterally together with simple aspiration of the abscess by means of a needle inserted through a suitably placed burr hole. The aspiration can be repeated as required and is followed by the local injection of 1 to 2 ml. of a solution of the appropriate antibiotic. Many surgeons also inject 0 5 ml of Thorotrast to delineate the abscess cavity in X-ray films, a measure which is useful in subsequently checking the diminution in size of the abscess and its ultimate cicatrization (Fig. 23 12). The burr hole itself is made not through the wall of an infected mastoid antrum or frontal sinus, but through healthy bone at a convenient adjacent site The older operative procedures in which the abscess cavity was drained into the mastoid antrum or frontal sinus have now been discarded as they

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Symptoms The clinical picture of the early invasive stage of intracranial infection is characterized by severe headache, vomiting, slowing of the pulse and drowsiness passing into coma epileptic attacks occasionally occur There are also localizing neurological signs depending upon the part of the brain which is involved. Thus in a left temporal lobe abscess one usually finds aphasia, right lower facial weakness, and right-sided homonymous hemianopia. Unless pyogenic meningitis supervenes, the course of an intracranial abscess is afebrile. Papilloedema may or may not be present. There is thus seldom any difficulty in concluding that an intracranial complication has supervened. Once the chronic stage of encapsulation is reached the clinical picture is that of a circumscribed space-occupying lesion. Occasionally however the stage of invasion may pass off quietly and the abscess then mimics a neoplasm in the way its symptomatology unfolds.

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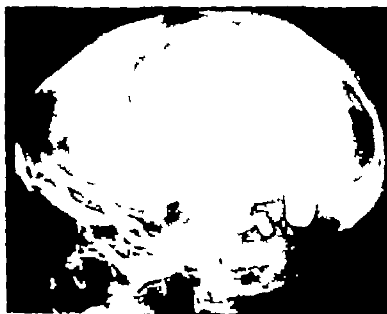


FIG. 23 12. TWO ABSCESS CAVITIES IN THE CEREBELLUM EACH CONTAINING THOROTRAST THE SMALLER IS CONTRACTING AND UNDERGOING CICATRIZATION.

and second the eradication of the source of infection. Now that antibiotics can do so much to limit and control the invasive stage of encephalitis, the treatment of cerebral abscess has been simplified In general it consists of the administration of the appropriate antibiotic (most often penicillin) in adequate amounts, either orally or parenterally together with simple aspiration of the abscess by means of a needle inserted through a suitably placed burr hole. The aspiration can be repeated as required and is followed by the local injection of 1 to 2 ml. of a solution of the appropriate antibiotic. Many surgeons also inject 0 5 ml. of Thorotrast to delineate the abscess cavity in X-ray films, a measure which is useful in subsequently checking the diminution in size of the abscess and its ultimate cicatrization (Fig. 23 12) The burr hole itself is made not through the wall of an infected mastoid antrum or frontal sinus, but through healthy bone at a convenient adjacent site The older operative procedures in which the abscess cavity was drained into the mastoid antrum or frontal sinus have now been discarded as they

were often complicated by herniation of brain tissue around the drainage tube, as well as by secondary infection of the abscess cavity

Aspirations are repeated at intervals of a few days or a week until the cavity contracts down. Simultaneously the patient's progress is checked regarding clinical improvement, and the lumbar cerebrospinal fluid examined at intervals to ensure that it returns to normal If progress is not satisfactory a second abscess loculus or even a second independent abscess should be suspected and its presence or absence can usually be determined by repeating carotid arteriography or ventriculography The second loculus or abscess can then be aspirated through either the same or another burr hole.

Generally an abscess thus treated by repeated aspirations plus the local injection of antibiotics will soon contract down and heal by cicatrization. If however pus keeps reaccumulating, its excision should be undertaken. Such excision is practicable once the abscess has developed a tough capsule (a process which takes about three to four weeks and can be judged from the pyograms) when the abscess can be dissected out like a tumour Otherwise in chronic cases infection may linger and recur later

Attention must also be directed at some appropriate stage towards treatment of the primary focus, otherwise reinfection or a fresh abscess may develop In general, during the acute stages it is the cerebral abscess which will cause death, hence its treatment carries first priority But as the cerebral abscess comes under control a chronic otitis media or an infected frontal sinus should be treated by a radical mastoidectomy or a drainage operation In thoracogenic abscesses secondary to bronchiectasis, removal of the affected pulmonary tissue should be considered after the cerebral abscess has been cured.

Late Complications These include recrudescence of the abscess, an outcome which is unlikely if it has been properly treated and if the source of infection has been eradicated Another complication is epilepsy which occurs in from 30 to 40 per cent It is seldom disabling, and can usually be



FIG. 23 13 CHRONIC OSTEOMYELITIS OF THE FRONTAL BONE.

controlled with anticonvulsant drugs. If the epilepsy proves intractable however excision of the cicatrized area should be contemplated

Osteomyelitis of the Skull This is uncommon nowadays It is usually secondary to acute frontal sinusitis, but it may also follow punctured wounds or result from metastatic blood stream infection The leading symptoms are intense pain in the affected part of the cranium accompanied by marked œdema of the scalp focal tenderness and pyrexia Formerly the prognosis was gloomy and heroic operations for removing all the affected cranium were carried out Antibiotic therapy has now made it possible to limit the spread of infection and even secure resolution without sequestrum formation If however a sequestrum forms, it is generally in the inner table. The clinical signs are those of focal tenderness and œdema of the overlying scalp while the radiographic changes of reaction in the surrounding healthy bone are usually not apparent for four to six weeks (Fig. 23 13) The treatment is then to incise the scalp open the outer table of the skull over the sequestrum and remove it Once the piece of dead bone is removed healing usually occurs promptly

Extradural Abscess. A localized extradural abscess may form during the course of osteomyelitis of the skull or as an intermediate stage between

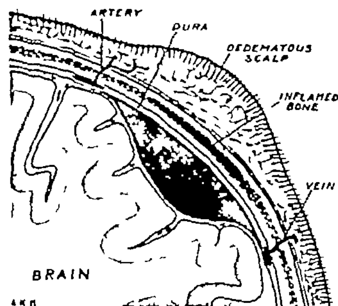


FIG. 23 14 SUBCRANIAL SUPPURATION INVOLVING THE OVERLYING BONE AND CAUSING AN ŒDEMATOUS CONDITION OF THE SCALP—POTT'S PUFFY TUMOUR.

otogenic or rhinogenic infections and a brain abscess. In neither instance does it usually reach a sufficient size to cause symptoms referable to itself its symptoms remaining obscured by those of the primary condition or of its other complications. In the older literature reference was often made to Pott s puffy tumour (Fig. 23 14) which was œdema, or an abscess, of the scalp overlying an area of focal osteomyelitis of the skull with an underlying extradural or subdural abscess. Such a condition is rare nowadays

Subdural Empyema. Occasionally instead of a cerebral abscess forming as a complication of chronic ear or sinus disease, a rapidly spreading subdural abscess appears. There is usually in addition infective and pyogenic

frontal craniotomy If an osteoma is present the intracranial roof of the frontal sinus is removed The fistulous track is then covered over with a graft of fascia lata, in much the same way as post traumatic cerebrospinal rhinorrhœa is treated

Occasionally an osteoma of the frontal sinus is complicated by the development of a spontaneous aerocele (Fig. 23 15)

Intractable Focal Epilepsy The treatment of this condition is a field of surgery which is steadily expanding. Increasing knowledge and experience reveals that fewer cases of epilepsy can now be regarded as "idiopathic" while an increasing proportion are coming to be recognized as focal in origin and consequently symptomatic. The clue to the focal origin of the seizures is afforded by a study of the aura (or initial clinical phenomena) correlated with the neurological, electroencephalographic, and neuroradiological findings. If the epilepsy cannot be controlled by drugs and is of disabling frequency while the various investigative data indicate that it is arising in an accessible site, operation may be undertaken. The location of the focus can then be confirmed by electrocorticography as well as by judging the effects of electrical stimulation of the cortex. Frequently some macroscopic abnormality is revealed, such as a scar malformed gyrus or unsuspected tumour which can be removed. The usual finding is that 25 per cent. of patients are subsequently cured, 50 per cent. have their seizures appreciably diminished and 25 per cent. are unchanged.

Hyperkinetic Motor Disorders. In recent years many advances have been made in the surgical treatment of some of the hyperkinetic motor disorders, notably Parkinsonism, choreoathetosis hemiballismus, spasmodic torticollis, and other muscular dystonias. These conditions have in common abnormal involuntary movements and increased muscular rigidity and their clinical manifestations are described in textbooks of medicine or neurology The underlying pathological processes in each of them remain obscure, and likewise the mechanisms by which the movements are produced.

The original surgical interventions in Parkinsonism included excision of portions of the motor cortex in the contralateral cerebral hemisphere or section of the descending pyramidal tract in the midbrain or cervical spinal cord. As a side effect, however these operations were followed by some degree of weakness, and they have now been superseded by procedures which destroy parts of the basal ganglia or thalamus of the opposite cerebral hemisphere. The targets aimed at include the medial and inferior portions of the globus pallidus or the nucleus ventrolateralis of the thalamus. Various methods of achieving this destruction are now under trial and they necessitate the introduction of electrodes or cannulæ by stereotactic methods so that these structures can be destroyed either by electrocoagulation or thermocoagulation by electrolysis, by the injection of alcohol, or by the placement of radioactive yttrium or gold rods. Thus this field of surgery is still being explored and the long term results are not yet known. However marked lessening of the Parkinsonian tremor and rigidity have been noted in many patients without the simultaneous appearance of weakness. It would seem therefore, that operation is justified in any patient under the age of sixty years who is disabled by these features. Operation however is contra indicated in cases with dementia and it also does not improve speech. There is a slight but variable risk of hemiplegia with the various procedures.

Pallidal surgery is under trial for choreoathetosis, spasmodic torticollis,

hemiballismus, and other dystonias but the results, although occasionally successful, are not promising Many cases of hemiballismus of recent onset will subside spontaneously but intractable examples as well as severe and long-continued cases of choreoathetosis can sometimes be benefited by pyramidal tract section in the contralateral midbrain (pedunculotomy) Intractable spasmodic torticollis can be benefited by division of the anterior and posterior roots of the upper three cervical nerves on both sides (anterior and posterior rhizotomy) combined with section of the spinal part of the accessory nerve This operation however, produces as a side effect some weakness of the neck muscles.

Chapter 24

BRAIN TUMOURS

Introduction

Brain tumours still provide the major part of the work of neurosurgeons. The progress in their management has been intimately connected with increased knowledge of the pathology and clinical course of the tumours themselves, with more accurate methods of diagnosis and of course with improvements in operative techniques. Brain tumours as a group are probably much more common than is generally realized, approximately one new case arises for every 4 000 to 5 000 people each year They are, however not a homogeneous group, but include a wide variety of neoplasms with differing age indices, sites of election, frequencies and of widely varying degrees of malignancy By common consent some non-neoplastic conditions (*e g* cysts, tuberculoma) are also included in the term tumour Many are favourable from the operative viewpoint.

Classification of Brain Tumours

No completely satisfactory and universally accepted classification of brain tumours has yet been agreed upon The following covers most varieties in order of frequency

Glioma. Incidence, about 50 per cent. of all brain tumours. Subtypes
- *Astrocytoma* benign and malignant (astroblastoma and glioblastoma multiforme)
- *Ependymoma,* benign and malignant (ependymoblastoma)
- *Oligodendroglioma,* benign and malignant.
- *Neuro-astrocytoma* benign and malignant.
- *Medulloblastoma* malignant

Meningioma. Incidence, 10 to 20 per cent.

Neurinoma. Incidence, 5 to 10 per cent.

Pituitary Tumours. Incidence, 5 to 10 per cent Subtypes
- *Chromophobe Adenoma*
- *Chromophil Adenoma*
- *Adenocarcinoma.*

Pineal Tumours. Incidence, 2 to 4 per cent.

Tumours of Blood Vessels. Incidence, 2 to 4 per cent. Subtypes
- *Angioma.*
- *Hæmangioblastoma*

Congenital Tumours. Incidence, 5 to 10 per cent Subtypes
- *Craniopharyngioma*
- *Chordoma*
- *Epidermoid and Dermoid Cyst*
- *Colloid Cyst of Third Ventricle*

Granuloma Incidence 1 to 2 per cent Subtypes
Gumma
Tuberculoma
Miscellaneous Tumours. Incidence 1 to 2 per cent Subtypes
Choroid Plexus Papilloma
Hydatid Cyst
Metastatic Tumours. Incidence 5 to 10 per cent Subtypes
Bronchogenic Carcinoma
Carcinoma of Thyroid Breast Alimentary Tract etc.
Hypernephroma
Melanoma

Pathology of Brain Tumours

Glioma This type forms approximately half of all brain tumours. Derived from cells of the glial series they comprise a wide variety of tumours ranging from some of the most benign tumours occurring in the body to many of the most malignant Difficulty in classifying them is occasioned by the fact that in the more malignant gliomata the predominant cell type and the histogenic complexion of the tumour often varies from one part of the



A



B

FIG 24 1 CEREBRAL ASTROCYTOMA. A. THE SURFACE OF THE CEREBRAL HEMISPHERE SHOWING AN ASTROCYTOMA B THE CEREBRAL HEMISPHERE AFTER EXCISION OF THE ASTROCYTOMA.

tumour to another Attempts to classify them on the basis of the primary glial type cells or their embryonic precursors have led to the most elaborate classifications, but such elaborations have usually failed to satisfy either the clinician or the pathologist. The classification employed here follows the teachings of Kernohan who regards the malignant tumours as derived by dedifferentiation from the simpler glial cells rather than from their undifferentiated and often mythical embryonic precursors.

Astrocytoma This is derived from the astrocyte group of cells. The benign astrocytomata are not as common as the malignant varieties. They are met with chiefly in the cerebellum during childhood. Here they form circumscribed tumours which are often associated with cyst formation, and if such tumours are excised, complete cure results. A similar histologically benign astrocytoma found in the cerebral hemisphere, both of adults and children, is often of a slowly growing but infiltrating character and hence is

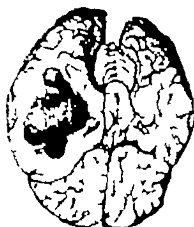


FIG 24 2. GLIOBLASTOMA MULTIFORME.

apt to recur following excision (Fig. 24 1) Some cerebral astrocytomas may also be cystic.

Malignant astrocytomata are unfortunately more common than the benign and they range in complexity and malignancy up to one of the commonest and most malignant forms of all, the so-called *glioblastoma multiforme* This contains glial cells of diverse degrees of dedifferentiation and complexity and accounts for at least half the gliomata, or about a quarter of all brain tumours. There are several varieties, but each is characterized by rapid and extensive spread throughout the white matter of one or both cerebral hemispheres, and is often associated with necrosis and hæmorrhage in its central portions where growth of the tumour has outstripped the blood supply (Fig 24 2). Cyst formation is common.

Intermediate between the benign astrocytoma and these highly malignant forms, are tumours of intermediate malignancy the *spongioblastoma polare* and the *astroblastoma* of earlier terminologies. The spongioblastoma polare occurs most often within the optic nerve or optic chiasm In addition many pineal tumours come within the malignant astrocytoma categories

Ependymoma. This forms about 5 per cent. of all brain tumours, and is a heterogeneous group of tumours of varying degrees of malignancy Derived from ependymal cells they form tumours within some part of the ventricular

system, the central canal of the spinal cord or the filum terminale of the cauda equina. The more benign varieties are circumscribed and some of them are slow growing and suitable for excision The malignant varieties, however are rapidly growing and some of them spread by seeding throughout the subarachnoid spaces, forming either multiple metastatic tumours through out the nervous system, or a diffuse carpet of tumour throughout the basal cisterns, the spinal subarachnoid space and other cerebrospinal fluid pathways.

Oligodendroglioma This form is considered to account for 1 to 2 per cent of all brain tumours. Derived from oligodendrocytes most of them are slow growing tumours developing gradually over the years Many of



FIG. 24 3 OLIGODENDROGLIOMA, SHOWING PATCHY CALCIFICATION OF THE FRONTAL LOBE.

them are partially calcified and they are visible on skiagrams as areas of patchy calcification (Fig. 24 3). Experience with the surgery of epilepsy however has suggested that tiny oligodendrogliomata, not discernible on straight radiographs or on ventriculography may be responsible for an un known but appreciable proportion of cases of chronic epilepsy A small proportion of oligodendrogliomata become malignant and then seed throughout the subarachnoid space, much as do the malignant ependymomata.

Neuro-astrocytoma This is another uncommon but variegated variety of new growth in which tumour nerve cells are present in association with tumour glial cells. Various names have been applied to different types including ganglioneuroma, gangliocytoma, and neuroblastoma

Medulloblastoma This constitutes 2 to 3 per cent. of all brain tumours. It is a malignant tumour composed of small uniformly round cells and it has a highly characteristic situation and symptomatology It arises from the roof of the fourth ventricle in children, being derived from embryonic pre

cursor cells in that region, known as medullocytes. As it grows, the medulloblastoma fills the fourth ventricle. Its symptoms are those of a mid-cerebellar tumour In the advanced stages the medulloblastoma seeds throughout the subarachnoid space Both the primary tumour and the seedlings, however are often sensitive to X ray therapy



FIG 24 4 MENINGIOMA, SHOWING PSAMMOMA FORMATION.

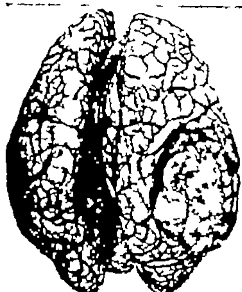


FIG. 24 5 LARGE MENINGIOMA IN THE RIGHT PARIETAL REGION.

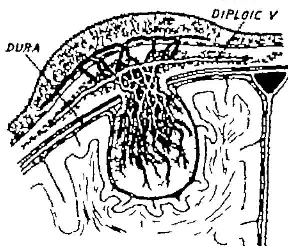


FIG. 24 6. DRAWING DEMONSTRATING THE INCREASED VASCULARITY IN THE DIPLOIC VEINS IN THE REGION OF THE MENINGIOMA.

Meningioma. The meningiomata, also called dural endotheliomata dural fibromata, are the second largest group of brain tumours and by and large they are among the most favourable for surgical intervention The primary cell is of arachnoidal origin, but several histological variants are seen. Thus some tumours are primarily endotheliomatous others are largely fibrous, some are characterized by psammoma bodies (Fig. 24 4), and a few are chondrogenic or even osteogenic. The typical meningioma forms a



Fig. 24 7 Meningioma (right) and the Bone Flap (left) Removed at Operation.
The bone flap shows a large hyperostosis It was boiled and replaced as a graft.

rounded mass of varying size attached to the dura and invaginating, but not invading, the underlying brain (Fig. 24 5) With a large tumour however the underlying cortex becomes necrotic. The tumour itself tends to be vascular receiving its blood supply from both the cortical and meningeal vessels. The skull over the areas of dural attachment is usually involved (Fig. 24 7) Sometimes it is locally hyperostotic due to extension of tumour cells along the Haversian systems. At other times the skull may be eroded from within by extensions of the tumour In all cases the affected portion of the skull shows an increased vascularity of the diploë (Figs. 24 6 and 24 7) These localized skull changes of hyperostosis, erosion and increased vascu larity may give rise to characteristic or suggestive appearances in straight skiagrams (Fig. 21 8).

The meningiomata have certain sites of election, of which the para sagittal region in relation to the Pacchionian bodies is the commonest.

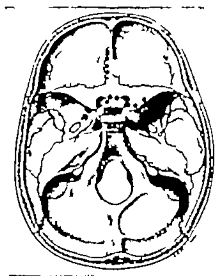


Fig 24 8. The Base of the Skull, showing the Common Sites for Meningiomata.

Occasionally a tumour in this situation may involve and occlude the superior longitudinal sinus. Other relatively common sites include the convexity of the skull distant from the sinus, the Sylvian region and certain basal and deep seated regions, such as the cribiform fossa (olfactory groove), sphenoidal ridge, tuberculum sellæ (suprasellar region), falx, tentorium cerebelli and the cerebellopontine angle (Fig. 24 8) An extracranial site lies on the sheath of the optic nerve within the optic foramen. Atypically a meningioma may be without attachment to the dura and instances are occasionally seen of meningiomata within the lateral ventricle which grow from the velum interpositum The duration of symptoms of a meningioma varies usually from three months to three years, but wide variations on both sides of this range are seen.

Neurinoma. These tumours arise from the sheath of a cranial nerve,



Fig. 24 9 Acoustic Nerve Tumour.

and are variously termed neurinoma, neurofibroma and schwannoma. Histologically they consist of interlacing bundles of spindle-shaped cells. The only common site is on one or other acoustic nerve, but occasionally they also occur on the sensory root of the trigeminal nerve in relation to the Gasserian ganglion. The tumours are usually single, but occasionally they are multiple. They form slowly-growing, ovoid, circumscribed masses which, because of their predilection of sites, are a common cause of the cerebellopontine angle syndrome (Fig. 24 9). There they produce symptoms by indenting the brain stem and distorting the adjacent cranial nerves.

Pituitary Tumours. These arise from the anterior hypophysis within the sella turcica. Histologically they consist of two main types, one in which chromophobe pituitary cells predominate (Fig. 24 10) and the other eosinophil cells. Mixed varieties, however occur Both main types produce endocrine disturbances. The *chromophobe adenoma* which is the commonest, is often associated with the clinical picture of " pituitary eunuchism " characterized by a smooth soft skin feminine type of hair distribution, amenorrhœa in the female and loss of sexual urge and a paucity of beard development in the

male The *eosinophil adenoma* is associated with the well known co[illegible] of acromegaly Both types of pituitary tumour also produce sympt[illegible] expansion As the tumour grows, the sella turcica becomes ex[illegible]

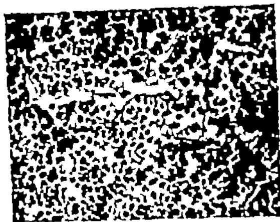


FIG. 24 10 CHROMOPHOBE ADENOMA OF THE PITUITARY



FIG 24 11 PIT[illegible] TUMOUR COMP[illegible] THE OPTIC CHIAS[illegible]

from within and parts of its wall become eroded The co[illegible] direction of expansion thereafter is upwards, when the tumour ma[illegible] beneath the optic nerves and chiasma and compress these st[illegible] (Fig. 24 11). Failing vision is therefore a common symptom and the s[illegible] for which surgical intervention is usually sought. Basically the[illegible] produced is generally one of bitemporal hemianopia, but the precis[illegible] depends upon the degree of extension upwards, the canting of the c[illegible] to one or other side and the prefixation or postfixation of the optic[illegible] in relation to the sella turcica (Fig. 24 12). Typically the initial def[illegible]

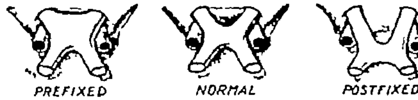


FIG. 24 12. THE RELATION OF THE OPTIC CHIASMA TO THE PITUITARY [illegible]

visual fields involves the peripheral portions of the upper quadrant[illegible] temporal field (Fig. 24 13), but often with a prefixed chiasma the init[illegible] is a hemicentral scotomatous one, the peripheral field still remai[illegible] served (Fig. 24 14). Simple confrontation methods of visual fiel[illegible] therefore, are not sufficient to delineate the defect, but recourse mus[illegible] to quantitative studies employing the Bjerrum screen as well as the p[illegible]

Pituitary tumours can also extend in other directions, a fact wh[illegible] widely known. They can extend upwards in front of the chiasma t[illegible] the clinical picture of a bifrontal lobe tumour They can extend b[illegible] and upwards to invaginate the floor of the third ventricle and [illegible] produce raised intracranial pressure from obstruction of the third [illegible] They can extend backwards and laterally to produce the clinical p[illegible] brain tumour characterized by homonymous hemianopia. Oc[illegible]

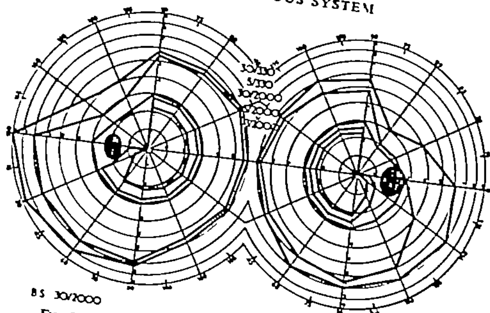


FIG. 24 13 VISUAL FIELD CHART SHOWING A COMMON PATTERN OF BITEMPORAL HEMIANOPIA.

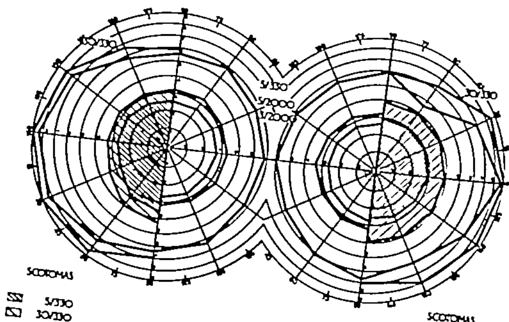


FIG 24 14 VISUAL FIELD CHART SHOWING HEMICENTRAL SCOTOMATA OF BITEMPORAL HEMIANOPIA.

There is yet a third type of pituitary adenom... Derived from the basoph... cells it is, ... *ll adenoma.* the adrenals, seen in so... of Cushing ... hyperplasia of however remain confin... turcica ... tumours, field changes or other ...on. Until ... oduce visual the clinical picture have ... to radi... to relieve

and partial or total adrenalectomy but successful attempts have also been made in treating these tumours by hypophysectomy

Pineal Tumours. Tumours of various types arise in the pineal region but none are common. Most of them probably come within the gliomatous group (Fig. 24 15) The classical pinealoma is a malignant tumour composed of two types of cells, one resembling lymphocytes and the other being composed of large clear vesicular cells (Fig 24 16) Other tumours in this region

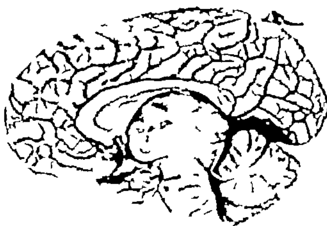


FIG. 24 15 SECTION OF THE BRAIN, SHOWING A PINEALOMA.



FIG. 24 16 PINEALOMA.

belong to the malignant ependymoma or malignant *astrocytoma series.* Some authorities consider that all these various tumours are primarily teratomatous in origin the differences in type resulting from differing malignant changes. Occasionally a true and benign teratomatous *tumour* is found here.

Blood Vessel Tumours. In most text books two types of blood vessel tumour are described, but we now know that the *angioma* is generally the result of a malformation rather than of a neoplasm. The *most prominent* variety sometimes called a *cirsoid angioma*, consists of a tangled mass of arteries and veins, and is more correctly described as an *arteriovenous fistula* (Figs. 24 17 and 24 18). It is a not uncommon cause both of epilepsy

and of intracranial hæmorrhage. Its true incidence is not known, but arteriographic studies show that it is certainly higher than the 2 per cent. incidence of all brain tumours once ascribed to it.

The *hæmangioblastoma* is a true neoplasm, and occurs characteristically in the cerebellum of adults. There it forms circumscribed vascular tumour masses, often associated with cyst formation in the white matter the tumour forming a mural nodule projecting into the cyst. Histologically the tumour tissue is composed of endothelioid cells with many small and large vascular sinuses between solid masses of such cells. Many of these tumours are slow growing and exacerbation of symptoms is due to the accumulation of faintly yellow and highly proteinous cyst fluid Lindau called attention to the fact that these tumours may be associated with an angioma of the retina (Hippel s disease) and with cystic disease of the pancreas and kidney From the surgical



FIG. 24 17 ARTERIOGRAM SHOWING CIRSOID ANGIOMA OR ARTERIOVENOUS FISTULA OF THE FRONTAL LOBE.



FIG. 24 18 ARTERIOVENOUS FISTULA EXPOSED AT OPERATION.

viewpoint the tumours in the cerebellum can usually be removed with complete and permanent relief of symptoms.

Congenital Tumours. *Craniopharyngioma* This is a generic term used to describe a group of tumours derived from the hypophyseal duct during the development of the pituitary gland and known variously as hypophyseal duct tumours, Rathke s pouch tumours, adamantinomas and craniopharyngeal duct cysts. These tumours vary in complexity from simple, squamous epithelial-lined cysts to tumours composed of solid epithelial cells. They may be situated within the sella turcica, in the suprasellar region or even within the third ventricle. The cysts contain fluid with a high content of cholesterin crystals. Some, particularly the solid varieties, are partially calcified and show up as areas of irregular calcification in straight X ray films.

These tumours occur most frequently in childhood or young adult life and are often associated with symptoms of dyspituitarism in the form of dystrophia adiposogenitalis (Fröhlich s syndrome) When situated in the suprasellar region they produce failing vision from pressure involvement of the optic nerves and chiasma and when situated within the third ventricle they may produce internal hydrocephalus with its concomitant signs of raised intracranial pressure The surgical story of these tumours, however

is a discouraging one for although histologically benign they have extensions which insinuate themselves among surrounding structures All too often complete removal is thus impossible and recurrence occurs

Chordoma This is a very rare tumour of notochordal origin It is composed of pink jelly like tissue a characteristic site is the dorsum sellæ

Teratoma These tumours may take the form of epidermoid or dermoid cysts. The *epidermoid* type is also known as a *cholesteatoma* or pearly tumour for it is composed of a mass of solid white completely avascular material composed of keratin and cholesterol surrounded by an outer membrane of flattened condensed epithelial cells Such tumours are benign and of very slow evolution They occur in certain characteristic sites of which the diploe of the skull lateral ventricle pineal region cerebellopontine angle cerebellar vermis and the cisterna magna are all well recognized These cholesteatomata must not be confused with the commoner cholesteatoma of middle ear origin, which is a mass of chronic débris resulting from long-continued otitis media. A *dermoid cyst* is rarer occurs in much the same sites and also contains other dermal structures such as hair and teeth A true teratoma containing mesodermal as well as ectodermal structures such as bone or muscle is very rare.

Colloid Cyst of the Third Ventricle This takes the form of a small rounded cyst, usually between 1 and 2 cm diameter which projects downwards into the third ventricle from its roof It leads to intermittent obstruction of the ventricular system producing symptoms and signs of raised intracranial pressure. The lesion is benign, can be demonstrated by ventriculography and can be relieved by surgery

Granuloma. To an earlier generation these were a common group of tumours, but they are now becoming very rare indeed. Two distinct types are recognized First is the *gumma* which usually occurs in the cerebral or cerebellar cortex arising from the meninges. Second is the *tuberculoma* which usually involves the white matter of the cerebral or cerebellar hemisphere. A tuberculoma should be suspected in all patients with symptoms of brain tumour who have tuberculous lesions elsewhere in the body such as in the lungs. With modern antibiotics the tumour can be excised with reasonable safety

Miscellaneous Tumours. *Choroid Plexus Papilloma* This occurs in less than 1 per cent. of patients with brain tumour mainly in infants and children It may grow over the years to a large size, but remains benign. The usual symptomatology is that of a slowly progressive hydrocephalus, presumably from excess secretion of cerebrospinal fluid, but very occasionally it can also cause subarachnoid hæmorrhage It produces a negative shadow on ventriculography

Hydatid Cyst This is due to the larval stage of *Tænia echinococcus* and is occasionally seen in those countries where hydatid disease is endemic.

Metastatic Tumours. Although malignant gliomata do not seed to other parts of the body but remain confined to the central nervous system certain malignant neoplasms arising elsewhere in the body commonly give rise to blood-borne metastatic lesions in the brain. Indeed from 5 to 10 per cent. of all cases of brain tumour are due to metastatic carcinoma and sarcoma arising from an extracerebral source. These secondary lesions are often multiple.

The most frequent source of a metastatic tumour is carcinoma of the

lung and hence, in the investigation of all patients suspected of brain tumour *radiography of the lungs should be a routine investigation.* Other sources of metastatic lesions include cancer of the breast, thyroid and alimentary tract, as well as malignant melanoma (Fig. 24 19) The prognosis in all such cases is generally hopeless for the metastasis is rarely single. Some metastatic carcinomas of mammary origin, however are benefited by hypophysectomy or by bilateral adrenalectomy

Metastasis from a hypernephroma, however is usually solitary and several case histories have been reported of the successful removal of such a metastatic tumour followed by nephrectomy with subsequently many years of useful life.



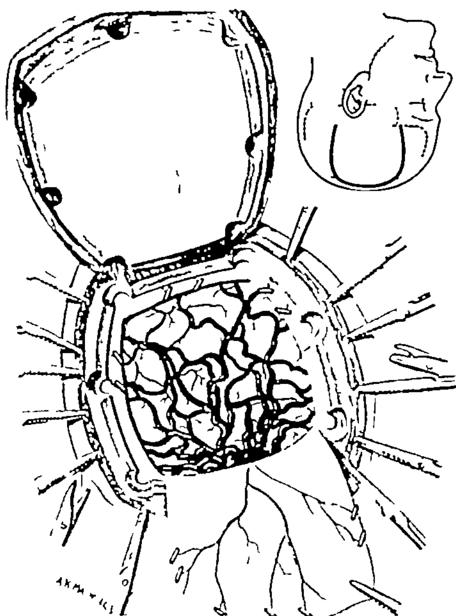
FIG. 24 19. METASTATIC MALIGNANT MELANOMA OF THE CEREBRAL CORTEX.

Symptomatology of Brain Tumours

A discussion on the detailed symptomatology of brain tumours is more appropriate to a text book of medicine than to one of surgery It is to the physician and particularly to the medical neurologist that most patients with brain tumour are referred in the first instance. It is essential, however that the surgeon who operates on the brain should also be versed in neurological diagnosis, because his is the ultimate responsibility for deciding the localisation of the tumour the time of operation and by what route it shall be conducted. In this section, therefore we shall confine ourselves to general principles, leaving the detailed consideration of symptoms and signs of different regions of the nervous system to neurological text books.

The symptoms produced by a brain tumour depend mainly on its site and on its pathological nature. The first of these factors determines the neurological localising symptoms and signs, and the second their rate of development. Thus a tumour in an "eloquent part of the brain like the motor cortex will give rise to more marked and more numerous signs than will a tumour in a "silent" area like the frontal pole or the cerebellar vermis. Again, a malignant and rapidly growing tumour will generally give rise to signs earlier and more intensively than a benign and slowly-growing lesion

PLATE 2



HÆMANGIOMA OF THE BRAIN.
The small drawing shows the incision.

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There are however other factors and in general we may say that a tumour in any given site may produce symptoms in one of four ways (*a*) By compressing or infiltrating adjacent neurological structures (*b*) By exciting the adjacent cerebral cortex thereby producing symptoms such as focal epilepsy (*c*) By raising the intracranial tension or (*d*) By causing distortions of the brain with consequent distant pressure effects, *i e* false localizing signs

The symptoms and signs produced by these factors all tend to be progressive

Localizing Neurological Symptoms and Signs. These are produced by the first two factors. They result in patterns of varying intricacy upon which a provisional localization of the tumour can often be inferred Thus for example a tumour in the frontal lobe may begin by causing occasional *grand mal* fits (which as the frontal lobe is a so-called " silent area " may not have any recognizable aura to them) followed after an interval by increasing lethargy and confusion Again a tumour situated in the motor cortex may cause Jacksonian motor seizures with or without loss of consciousness as well as the onset of a progressive hemiplegia Different patterns occur in different regions, and the same type of tumour in a comparable region will not produce quite the same clinical picture in every patient Malignant lesions tend to infiltrate and destroy and the signs they produce are permanent, but malignant lesions as well as benign can also produce signs by compression In this event if the compression lesion is successfully removed, the signs may well disappear

Symptoms and Signs of Raised Intracranial Pressure These features result not so much from the size of the tumour as from its situation in relation to the cerebrospinal fluid pathways, because the chief mechanism in producing raised intracranial pressure is an obstruction to the flow of cerebrospinal fluid. Thus a small tumour within or adjacent to either the third or the fourth ventricle will early produce raised intracranial pressure because such a tumour readily and directly obstructs a narrowed portion of the cerebrospinal fluid pathways. On the other hand a tumour in a cerebral hemisphere may grow to a large size (300 to 400 g.) before it produces signs of raised intracranial pressure The reason is that this second tumour cannot directly obstruct a narrowed part of the cerebrospinal fluid pathways, but instead produces its effect by displacing the medial portions of the hemisphere inwards, so that a secondary squeezing effect is exerted upon the third ventricle

The classical triad of symptoms due to raised intracranial pressure is (*a*) headache (*b*) vomiting and (*c*) papilloedema To these can be added radiological changes in the skull increasing size of the head in children mental slowing and in the later stages, increasing drowsiness. None of these components however is equally obvious in different patients and errors in diagnosis consequently arise. Headache when present is usually felt chiefly on waking in the morning and may be in any part of the head Headaches, however can be absent or not noticed, especially in children Vomiting often accompanies the headache, but in children without headache may be considered due to " bilious attacks or " cyclical vomiting." The recognition of papilloedema requires the skilled use of an ophthalmoscope and sometimes there can be reasonable grounds for divergencies of opinion on the appearances of the optic discs From the patient s viewpoint papilloedema

leads to progressive impairment of vision. It is, however drowsiness progressing to coma which most alarms the surgeon, for these are signs of great urgency *indeed they are the penultimate signs.* The surgeon has the right to expect that his patients will be referred to him before they reach that stage.

False Localizing Signs. These are produced by distant pressure effects of the tumour and add to the complexities of neurological diagnosis. Some examples will illustrate this. Thus, a large benign tumour of the right cerebral hemisphere may exert but little compression upon the motor cortex of its own side, but so markedly displace the brain stem to the opposite side that the left cerebral peduncle impinges upon the left edge of the tentorium cerebelli, and the left pyramidal tract within the peduncle is notched resulting in a *right-sided (i.e. ipsilateral) hemiplegia.* Again a tumour in the third ventricle or in either cerebral hemisphere may produce such a degree of uncinate pressure-coning that one or other posterior cerebral artery becomes pinched against the tentorium and thrombosed, leading to a complete homonymous hemianopia. This may lead to an interpretation of an occipital lobe tumour Yet another example is a tumour in the cerebellum which produces such a marked degree of internal hydrocephalus that mental symptoms suggestive of a frontal tumour are provoked.

Diagnosis of Brain Tumours

Difficulties in diagnosis may be further aggravated because there are several conditions other than tumour which can produce raised intracranial pressure or the features of a progressive focal cerebral lesion. In a short list of these we may place the following (*a*) Other space-occupying lesions, *e g* cerebral abscess, intracranial hæmatoma, etc (*b*) Pseudo-tumours (conditions which cause raised intracranial pressure but in which there is no space-occupying lesion), *e g* cerebral thrombophlebitis (otitic hydrocephalus and serous meningitis), essential arterial hypertension etc. and (*c*) Other focal neurological lesions, *e.g* internal carotid artery thrombosis, thrombosis of the smaller intracranial arteries, focal cerebral atrophies, meningovascular syphilis, etc.

The diagnosis and localization of a brain tumour is thus often a matter of great difficulty and uncertainty The initial basis of diagnosis is afforded by the methods of history taking and clinical examination developed by neurological physicians, but by such means alone it is not possible to make a reasonably certain diagnosis of tumour in more than 60 per cent. of cases, and even then the presumptive localization of the tumour may not be sufficiently precise to determine the best position for the craniotomy Indeed at the time of their reference to the surgeon, all that is possible to make in many cases is a diagnosis of suspected tumour Even when the clinical neurological diagnosis is reasonably certain, the surgeon will probably require some confirmation of this diagnosis together with more precise information of the site, size and nature of the tumour For this information enables the surgeon to place his craniotomy in the correct place and to approach the lesion in an expeditious and workmanlike fashion. He tries to avoid a blind craniotomy which, when fashioned, may prove to be in the wrong place.

Pre-operative Investigations. Nowadays it is seldom justifiable to operate on a patient without having first confirmed the localization and possible nature of the tumour by detailed skull radiography supplemented by special

measures, such as air encephalography ventriculography or carotid arteriography Among other investigations required are a skiagram of the lungs to exclude bronchial carcinoma electroencephalography lumbar puncture where necessary a blood count and grouping in case a transfusion during operation is required and the Wassermann reaction

No hard and fast rules can be given regarding the order of these various investigations. In general, if a tumour of the cerebral hemisphere is suspected, carotid arteriography can be performed but otherwise air studies are likely to give more certain information If there is no marked elevation of intracranial pressure (i.e absence of papillœdema) air encephalography can be carried out but if there is papillœdema ventriculography is indicated This latter investigation however and also the preliminary lumbar puncture should be deferred until the patient is on the threshold of the operating theatre. With the requisite information gained by one or more of these special investigations, the surgeon is in a position to decide the approach for operative treatment

Operative Treatment

General Principles. In the main the treatment of brain tumours is surgical removal whenever possible However with many rapidly growing and malignant tumours, the results of surgery are so deplorable both as regards post-operative disability and early recurrence that it is kinder not to operate. Yet it is not possible to be certain beforehand from the radiographic appearances what the pathological nature of the tumour will prove to be. Thus an expert radiologist or neurosurgeon will every now and then mistake the arteriographic appearances of a meningioma for a glioma, and vice versa. The following provisional rules may therefore be formulated

(1) If the patient is suspected of having a rapidly growing malignant tumour first obtain a histological confirmation of its nature by a needle biopsy and then leave the patient alone A needle biopsy is secured by making a burr hole at an appropriate site in the skull and then passing a brain needle into the tumour to suck out a fragment. Neuropathologists can rapidly stain and examine such fragments, either by smear or by frozen section techniques, usually giving a confident report within half an hour In this way a malignant tumour can be histologically verified and an unsuspected abscess, intracranial hæmatoma or cystic lesion will not be overlooked.

(2) If the clinical and radiological features suggest a benign and accessible tumour or a malignant tumour in a site where excision is possible (e g the frontal pole) proceed to a craniotomy

(3) If the clinical and radiological features suggest a slow-growing but inaccessible tumour for which removal is not feasible, one may consider some procedure to relieve intracranial pressure (e g decompression or ventriculocisternostomy) followed possibly by supervoltage X ray therapy

The principles of fashioning a craniotomy having been discussed elsewhere, the treatment of tumours of individual types will now be described. In general if malignant tumours are excluded the overall operative mortality of brain tumours should not exceed 5 per cent.

Treatment of Individual Types of Tumour *Gliomata.* The cerebellar astrocytomata seen in children and young persons are by far the most favourable members of the glioma group These tumours can usually be

excised with complete and permanent recovery of the patient. However they do not constitute more than 5 per cent. of all brain tumours

The highly malignant astrocytomata (glioblastoma multiforme) of the cerebral hemispheres are of unfavourable prognosis. The surgeon should merely content himself with securing a verification by needle biopsy Occasionally such tumours when present at the frontal poles can be excised. If a glioblastoma elsewhere in the hemisphere should be encountered during a craniotomy the surgeon can consider sucking out its central core (internal decompression) this procedure will temporarily improve the patient's condition. X ray therapy likewise has generally only a temporary effect on these tumours, relieving symptoms only for a while

Intermediate between these two extremes of the glioma range are a few cystic gliomata of the cerebral hemispheres. Some of these can be benefited by tapping the cyst and removing the tumour mass which forms a mural nodule jutting into the cyst A few such cases occasionally survive for many years.

Meningiomata In removing a meningioma of the vault or parasagittal region, the craniotomy should be so planned that the surgeon can remove not only the tumour itself but also its dural attachment as well as the hyperostosis in the skull. Otherwise the tumour may recur from the affected dura or bone. With tumours growing from the base it may not be possible to remove the bone or dura and the surgeon will then have to content himself by coagulating the affected area with diathermy As regards removing the tumour itself the first stage, once the tumour is exposed, is to divide the dura around its attachment, then the pia-arachnoid with its feeding vessels around its circumference. The tumour may then be dissected out intact, or if this is not possible, removed by scalloping with a rongeur or a diathermy loop. Meningiomata are usually vascular tumours, but with experience the surgeon should be able to remove most of them with a low mortality

Neurinomata The acoustic neurinoma is the only tumour which need be considered. It is approached by a unilateral posterior fossa craniotomy The cerebellar lobe is elevated exposing the tumour covered by a cap of arachnoid derived from the cisterna pontis. The surface of the tumour is gradually separated from the cerebellum and brain stem, and simultaneously its bulk is diminished by scalloping. As the operation proceeds the surgeon will have to decide whether to remove the tumour completely (extracapsular removal) or only its interior (intracapsular removal) The extracapsular removal has the advantage that the tumour will not recur but it has certain disadvantages, namely a somewhat higher mortality an almost inevitably complete destruction of the facial nerve with consequent unilateral facial palsy and a risk of slightly greater residua in the way of permanent cerebellar ataxia. The intracapsular operation is easier is less damaging to the brain stem spares the facial nerve but has an eventual recurrence rate of more than 50 per cent. In deciding between the two procedures the surgeon must take into consideration the individual patient, his age (complete removal is preferable for young patients), and his occupation (e.g in a pianist the intracapsular operation will minimize any subsequent post-operative ataxia).

Two procedures are available to correct the facial paralysis which follows a complete removal. The first is cranial nerve anastomosis, such as hypoglossofacial anastomosis and spinofacial anastomosis, and the second is a fascial sling operation performed by a plastic surgeon Both procedures

will only correct the facial appearances in repose but the facial asymmetry remains marked during emotional movements such as laughing and smiling The facial sling operation is quicker than the nerve anastomosis and avoids the long tedious period of facial exercises which are necessary with these latter procedures In the later stages the results are possibly not as good as after nerve anastomosis as the face is not animated

Pituitary Tumours The removal of a pituitary adenoma is essentially an intracapsular operation usually performed through a right frontal craniotomy (because most surgeons, being right-handed find that approach easier) A left sided craniotomy however is often indicated if the visual field changes and air encephalograms show the tumour extending markedly to the left side of the midline. The frontal lobe is elevated off the anterior fossa,

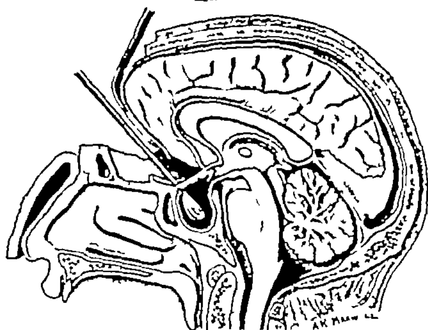


FIG. 24 20. REMOVAL OF THE CONTENTS OF A PITUITARY ADENOMA BY MEANS OF A SMALL LOOP CURETTE.
A subfrontal approach is used.

cerebrospinal fluid being sucked out of the basal cisterns to facilitate this manœuvre (Fig. 24 20) The tumour is usually found pressing up beneath the optic chiasma Its interior is then gutted, either with rongeurs or suction and as the tumour collapses its capsule is pulled away from the optic chiasma and nerves This operation in suitable cases should have a negligible mortality

Most surgeons follow their operations on eosinophilic adenomata with radio-therapy The consensus of opinion is that chromophobe adenomata are radioresistant. A few patients present recurrent symptoms after an interval of months or years and may then be subjected to further operation.

Pituitary adenomata are much like thyroid adenomata in that they can wax and wane spontaneously At one stage there was a vogue, which has still not died out, of treating all cases of pituitary tumour in the first instance by X ray therapy This course is to be deprecated because the treatment may provoke a transient swelling of the already enlarged gland with a consequent

increase in visual failure, which may prove permanent. Further although eosinophilic adenomata are often radiosensitive, chromophobe adenomata are generally resistant. The claims that have been made for radiotherapy can be accounted for by the spontaneous regression which sometimes occurs in these tumours

The chief indication for operation is failing vision and the mortality rates should not be more than 2 to 3 per cent. Generally some improvement in vision follows operation and sometimes this improvement is marked One other indication for surgery is seen in cases of acromegaly without visual loss but with intractable headache. Relief of headache is usually afforded by operation even after failure of radiotherapy The mechanism of production of headache is usually one of tension within the gland beneath an intact diaphragma sellæ, and the intracapsular operation possibly aids by relieving this tension.

Pineal Tumours Tumours in the pineal region can be approached directly through an occipital craniotomy but as most pineal tumours are usually irremovable and malignant, the mortality of direct intervention is very high indeed. Consequently most surgeons nowadays perform the palliative procedure of ventriculocisternostomy followed by radiotherapy Two types of this operation are practised In the first, anterior third ventriculostomy an opening is made in the anterior wall of the third ventricle (lamina terminalis) *via* a frontal craniotomy so that the third ventricle communicates directly with the *cisterna chiasmaticus*. In the second type, Torkildsen s operation, one or two fine bore polythene or rubber tubes are led from one or both lateral ventricles to the cisterna magna *via* an occipital craniotomy This second operation is the one usually performed, and the statistical results of such a procedure (which relieves the elevation of intracranial pressure consequent upon a blockage of the third ventricle) followed by radiotherapy are surprisingly gratifying. Relief of symptoms of longer than ten years duration has been reported in many cases.

Tumours of Blood Vessels The operative treatment of arteriovenous fistulæ (cirsoid angioma) depends on the accessibility of the lesion. If it is accessible, it should be excised otherwise the principal feeding arteries are clipped. *The cerebellar hæmangioblastomas are exposed by an occipital* craniotomy and dissected out. If a cyst is present, the aspiration of fluid will relieve pressure and facilitate removal.

Congenital Tumours The craniopharyngiomas are difficult tumours to treat. Very few of them can be excised completely because of the way the majority insinuate themselves among the various structures at the base of the brain Moreover they are not sensitive to radiotherapy Some of the tumours fortunately are slow growing and slow to recur and hence a partial removal may be followed by relief of symptoms for many years. Others develop recurrent symptoms within a few months.

Epidermoid and dermoid cysts can usually be excised if they arise in the skull vault. In the ventricles, however complete removal is not possible, but removal of the interior of the tumour leaving only small pieces of the epithelial lining is usually followed by relief of symptoms for many years.

The colloid cyst of the third ventricle can usually be diagnosed by its characteristic ventriculographic appearances. It can then be approached and removed *via* a right frontal craniotomy with removal of a core of frontal tissue which opens into the lateral ventricle opposite the foramen of Monro

Alternatively many of these cases can be benefited permanently by Torkildsen's ventriculocisternostomy for the symptoms they cause are purely those of third ventricular obstruction. Since the cyst is benign and seldom seems to increase in size it can be left alone.

Other Primary Tumours As these are all rare little need be said about them The gumma and tuberculoma can be excised and in these days of streptomycin and other antibiotics the dreaded complication of miliary tuberculosis which often supervened after operations on a tuberculoma, can now be controlled The choroid plexus papilloma likewise can be excised. A primary hydatid cyst is treated by carefully sucking out its membranes and by avoiding seepage or leakage of its fluid contents.

The Place of Radiotherapy In many centres it is customary in cases of inoperable or malignant brain tumours, particularly of the glioma series, to follow biopsy or partial operative removal by supervoltage X ray therapy Although the clinical impression is that this treatment is often beneficial, its statistical proof has not yet been forthcoming One difficulty in assessing the results is that many patients with gliomata will survive for years following a partial removal without radiotherapy

Pending the results of several long term studies now under way in which attempts are made to provide adequate controls, we may perhaps merely content ourselves here with some general impressions The malignant tumour which seems to respond most readily to radiotherapy is the medulloblastoma of childhood and because of the tendency to subarachnoid seeding the entire cerebrospinal axis has to be irradiated But, even with this tumour although some radiotherapeutic clinics have claimed survivals for as long as five years in nearly half their treated cases, the experience of most neurosurgeons in watching their patients subsequent progress is more dismal than this, and recurrence within two years seems almost inevitable. With other gliomata the immediate benefit is seldom so striking, but longer survivals do occur With the more malignant gliomata (glioblastoma multiforme) survival for longer than two years is rare although patients who have survived many years do exist.

In the absence of more definite information, neurosurgeons will probably continue to refer their less malignant cases of glioma for postoperative radiotherapy There is, however nothing to be gained by submitting a patient moribund with glioblastoma multiforme, to this therapy

Chapter 25

DISEASES AND INJURIES OF THE SPINAL CORD

Developmental Abnormalities

Spina Bifida This is the result of an incomplete union of one or more laminæ of the vertebral column with or without an associated abnormality of the spinal cord or its membranes. It is most common in the lumbosacral region, *next in the cervical vertebræ and least in the thoracic region.* Several grades are recognizable, ranging from those which are hidden and innocuous to extensive deformities incompatible with continued life.



FIG. 25 1 SPINA BIFIDA OCCULTA AFFECTING THE SACRUM.

Spina Bifida Occulta This is the term used when there is no protrusion of the meninges or their contents through the defect in the neural arch. *Most often it is seen as an incidental finding in X ray studies of the* lumbosacral region (Fig. 25 1) It is usually completely asymptomatic and there is generally no abnormality of the overlying skin. Occasionally however a tuft of hair (Fig. 25 2), an area of cutaneous pigmentation, or a subcutaneous lipomatous mass may overlie the defect.

Meningocele In the more severe grades of spina bifida a protrusion of the spinal meninges, with or without an associated abnormality of the spinal cord, is *present* *In a simple meningocele there is a sac like* protrusion of



FIG. 25 2. SPINA BIFIDA OCCULTA IN A GIRL AGED TEN YEARS.



FIG. 25
The child
paralysis
trophic c

the dural sheath containing cerebrospinal flu
of the spinal cord or its nerve roots (Fig. 25 4).
surface as a sessile or pedunculated swelling co
skin or by thin, bluish, translucent and
Lipomatous tissue may be associated with the
size from 1–20 cm. diameter or more. It
whenever the child strains or cries, while on
anterior fontanelle may distend

Meningomyelocele A more advanced gra
which spinal cord tissue often ectopic, as well
(Fig. 25 3). Meningomyeloceles vary in their
more advanced degree the function of the defor



This may result in paraplegia with paralysis of the lower limbs, incontinence, club feet and often trophic changes. It may also result in hydrocephalus due to an associated abnormality of the brain stem, cerebellum, and superior cervical cord known as the Arnold-Chiari malformation.

Arnold-Chiari Malformation. In this the brain stem is elongated and parts of the medulla, together with a tongue of cerebellar tissue, are drawn through the foramen magnum. This malformation has been thought to be secondary to the tethering of the lower end of the spinal cord in the meningomyelocele, thereby preventing the ascent of the lower end of the spinal cord which occurs during fœtal and early life.

Rachischisis This is the most severe degree of all. The deformed spinal cord is exposed to the surface, uncovered by epithelium and there is an associated complete paraplegia

The prognosis, as with cranium bifidum varies with the complexity of the abnormality and with the extent of other associated anomalies. In cases *of simple meningocele it is usually good, for the sac can be excised and the* deficiency in the skin and subcutaneous tissue made good by a plastic procedure. Unless the sac is thin and threatening to rupture, operation (which can be carried out readily under local analgesia) is best deferred until the infant is at least two weeks old In many cases it can safely be deferred until even later Cases of meningomyelocele can also be subjected to operation, but here judgment has to be exercised in respect of the extent of paralysis and the presence or progress of hydrocephalus. If the child is likely to be disabled by these defects, operation is inadvisable. Rachischisis is a condition not compatible with continued life.

Pilonidal Sinus and Cyst These comprise a wide range of developmental abnormalities which are akin to spina bifida when they result from defects in the closure of the neural cleft in fœtal life They are most common in the midline in the sacrococcygeal region, but can occur at higher levels of the spinal canal. The simplest form is a mere dimple in the sacrococcygeal region, but every degree of severity exists and includes sinuses of varying length and complexity which tend to link up with the spinal theca. Sometimes the actual sinus opening is closed, subcutaneous clefts or cysts being present. In the more complex forms lipomatous masses are found surrounding the deeper portions of the cysts in relation to the spinal theca.

Most of these abnormalities remain harmless throughout life, but if they become secondarily infected they are painful. The infection may be delayed until adult life. Acute infection is dealt with by antibiotics and drainage Chronically infected sinuses require a meticulous excision. The dissection may prove difficult and tedious and frequently leads down to the spinal theca. Some pilonidal sinuses may be produced by indriven hairs.

Traumatic Lesions

Injuries of the spinal column are frequently associated with or followed by injuries affecting the cord and its membranes. However the degree of spinal cord damage bears no constant relationship to the apparent severity of the skeletal injury Thus, one patient may sustain a severe compression *fracture of the spine or a* fracture-dislocation with little or no neurological sequelæ while the next patient with a comparable skeletal injury may sustain a severe or even complete paraplegia Again, particularly after neck injuries, a patient may sustain cord damage with little or no abnormality

being visible in the X ray films The surmise in such circumstances may then be either that there is an associated retropulsion of an intervertebral disc or that at the moment of injury the spine was dislocated and then reduced itself spontaneously In this section therefore the stress will be on injuries to the cord rather than its skeletal counterparts for which reference should be made to Chapter 15

Types of Spinal Cord Lesions. The spinal cord itself can be damaged in a number of ways. First it may be concussed Second it may be contused and the contusion may be associated with the development of medullary or extrathecal hæmorrhage Third it may be pulped Sometimes it may be compressed by a displaced fragment of bone but such compressions, although present at the moment of injury do not usually persist to a significant degree.

Attempts have been made to classify spinal cord injuries on the basis of the above pathological changes but from the clinical viewpoint such classifications are not as practical as the clinical one of whether the interruption of spinal cord function is complete or incomplete. In complete lesions there is absolute paralysis of voluntary movement complete loss of voluntary sphincteric control, and complete loss of sensibility below and including the level of the lesion with appropriate alterations in tendon reflexes and plantar responses. Anything less than this constitutes a partial lesion The distinction is of importance because when there are clinical signs of complete interruption, the paralysis is likely to remain complete, but if there is the slightest sparing of either voluntary motor power or sensibility some degree of recovery (and often a remarkable degree) can be expected The clinical appearances of partial spinal cord injury range from a mild monoplegia or hemiplegia to an almost complete paraplegia. Loss of pain and thermal sensibility dissociated from touch is also sometimes seen.

The Level of the Lesion The neurological picture varies with the level of the lesion In injuries of the cauda equina there is paralysis or weakness of the bladder and rectal sphincters and of the hamstring and leg muscles together with absent ankle jerks and anæsthesia in the saddle area. A similar picture may be present in injuries of the conus medullaris or lower end of the spinal cord With lesions of the thoracic cord the signs are those of a motor and sensory paralysis involving the lower limbs. In injuries of the lower cervical cord the arms are also affected Injuries of the C.8 and T 1 segments



FIG. 25 5 DISLOCATION OF THE FIFTH CERVICAL VERTEBRA ON THE SIXTH VERTEBRA, SHOWING THE ATTITUDE THE ARMS ADOPT

show in addition involvement of the intrinsic muscles of the hand A characteristic picture is seen when the lesion involves the sixth cervical segment, but spares the fifth (Fig. 25 5). At this particular level the arms are held abducted at the shoulders and flexed and supinated at the elbows. With lesions above the fifth segment, death is common through paralysis of the diaphragm as well as the intercostal muscles.

Prognosis In the past three stages were described in the life history of a patient with a gross or complete spinal cord lesion The first stage was that of " spinal shock " This occupied the first two or three weeks and was characterized by flaccidity and immobility of the muscles, by loss of tendon reflexes and by retention with overflow of the bladder If the patient survived the second stage was one of reflex hyperexcitability characterized by increased tone in the paralysed muscles, increased tendon jerks, involuntary reflex flexor spasms of the lower limbs and reflex emptying of the bladder The third stage then gradually supervened with progressive inanition due to bed sores and ascending renal infection leading to death. Even ten years ago the prognosis in complete paraplegia was exceedingly gloomy

Fortunately all this has changed, thanks mainly to the pioneer work of Ludvig Guttmann Nowadays, with proper management and training, patients with permanent paraplegia can look forward to an active life of social, domestic and industrial rehabilitation It is now realized that during the acute stage, the patient must be nursed horizontally and turned frequently from side to side " in one piece " to prevent pressure sores, until the spinal fracture consolidates. The patient is then trained to walk " on his arms " using crutches with his knees braced with calipers. He learns how to empty his bladder and bowels reflexly through manual pressure over the lower abdomen. Rehabilitation, even in complete paraplegia, has become worthwhile, so that everyone should be conversant with the general principles.

First aid Care of Spinal Cord Injuries. Careless handling in transportation of a patient with a spinal injury may quickly convert a relatively slight injury into a complete and irremediable one. The public must therefore be constantly reminded that any injured person unable to use arms or legs should not be moved until skilled help arrives. The head should not be raised even when giving a drink or a cigarette, nor should a pillow or folded blanket be placed beneath it.

The most important principle in the first-aid treatment of fracture-dislocations of the spine is to do nothing which will increase the bony deformity The patient should not be lifted off the ground unless he is on a stretcher or other rigid support. Reduction of the fracture should not be attempted but the patient should be transported supine, with the neck in slight dorsiflexion and with folded blankets on both sides of the head to prevent lateral movement. In fracture-dislocations of the neck and thoracic spine a folded blanket should be placed beneath the shoulders, and for fractures of the lumbar spine, beneath the loin, in order to produce slight hyperextension of the fractured region.

The transference of a patient from the ground to a stretcher requires the co-ordinated efforts of at least three people. One should grasp the chin and occiput and exert steady traction in the long axis of the body The second should grasp the ankles and exert countertraction along the same axis. The third should kneel beside the patient, reach across his body and grasp the patient s clothing near the shoulder and hip joint. The duty of the third

is then gently to rotate the patient on to his side while simultaneously the first two men exert their traction A fourth person if available then places the stretcher behind the patient and when this is done the whole team gently rotate the patient on to his back simultaneously sliding him on to the stretcher Throughout the whole series of manœuvres the two men at the head and feet maintain their traction The patient is then transported as speedily as possible to hospital

Hospital Treatment of Acute Spinal Injuries. On arrival at hospital the patient is transferred to bed with a comparable set of manœuvres to those already described A neurological examination follows as well as radiography of the spine to see whether there is bony encroachment upon the spinal canal. If there is, a lumbar puncture with employment of the Queckenstedt test is useful to see if there is a block to the flow of cerebrospinal fluid around the cord

The sequence of treatment to be employed in any individual case of spinal cord injury depends upon many factors, of which the degree of paralysis, the state of the bladder as well as the type of fracture rank high This treatment is best undertaken in a specialized spinal rehabilitation centre. In the following sections the principles outlined are those underlying the management of patients who show a considerable degree of spinal cord damage

Management of the Fractured Spine Hasty and forced manipulative manœuvres to correct the alignment of the spine should be avoided for they may further damage the cord or its roots. Although it is desirable to restore the displaced vertebræ to their normal position considerable recovery of the cord or cauda equina may occur in the presence of bony displacement without immobilization in a plaster cast or on a plaster bed Indeed plaster casts and beds are to be deprecated for spinal fractures with paraplegia as they almost invariably produce pressure sores.

The routine procedure advocated by Guttmann for dealing with traumatic paraplegia in the initial stages is for the patient to be placed on sorbo packs, with two or three additional pillows underneath the fracture. This produces a degree of hyperextension in order to restore normal curvature From this basic supine position, the patient is turned first to one side, then back to the supine position, then to the other side, every two hours, *day and night* The turning is carried out by three or four orderlies, and care is taken that the patient is always turned in one piece. This routine of constant turning is continued without interruption until the fracture consolidates or the dislocation reduces itself when the patient can be allowed up With this regular turning the development of pressure sores is unknown and in cases admitted with sores already developed, healing takes place in a short time.

With cases of fracture-dislocation of the cervical spine the use of skull calipers (Fig. 25 6) to permit of continuous weight extension (2 5 to 5 kg.) in the longitudinal axis is of great value. It can readily be combined with Guttmann s routine of regular turning. The value of open operations to correct fracture-dislocations of any part of the spine is problematical Such operations not only often weaken the spine and intensify the neurological symptoms but are often followed by aggravation of the skeletal defect. They should be employed with great circumspection.

Management of the Paralysed Bladder and Bowels The ideal to be aimed

at if the patient should be unfortunate enough not to regain voluntary bladder function, is the development of automatic micturition initiated reflexly by manual pressure over the lower abdomen The bowels in similar circumstances can be opened every second day by a small saline enema.

To gain this ideal, Guttmann advocates that every eight to twelve hours the bladder should be stimulated by gentle manual pressure If voiding does not occur the patient should then be catheterized. Intermittent catheterization using a soft rubber catheter is employed, and the patient given small doses of Sulphatriad and chlortetracycline for a protracted period It is possible by this method to keep the urine sterile for many weeks, by which time, even in complete cord lesions, automatic bladder emptying

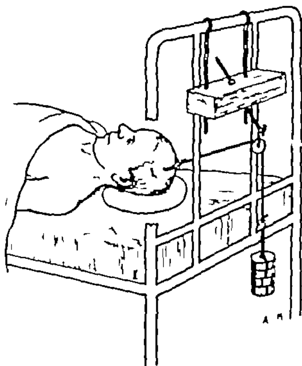


FIG. 25 6. SKULL CALIPERS *in situ* WITH WEIGHT TRACTION IN THE LONGITUDINAL AXIS FOR DISLOCATION OF THE CERVICAL SPINE.

may return. Should neurological recovery occur the return of normal bladder function will accompany it.

If in spite of careful aseptic catheterization, the urine becomes infected, a self retaining Foley catheter can be introduced and tidal drainage set up The bladder should be washed out daily with some mild antiseptic solution, and the catheter changed every second or third day Once the automatic function of the bladder has returned, the indwelling catheter should be removed. Suprapubic cystotomy is undesirable at any stage in the management of a paralysed bladder It leads to cystitis, ascending renal infection and a contracted bladder

The care of the bowels also needs special mention. As long as the rectum is paralysed and insensitive, frequent small doses of paraffin emulsion should be taken by mouth to soften the motions, while a saline enema administered every second morning will act as the stimulant to evacuate the rectum.

Management of the Later Stages In most cases of spinal cord injury some recovery of function ensues, often to a considerable degree As soon as the paralysed limbs begin to move again, they should be given active exercises with the object of getting the patient on his feet as soon as possible. If the fracture has not yet consolidated and the patient is ready to walk, a plaster cast may be fitted

In a small minority of patients a complete and permanent paraplegia persists. Only general principles in management can be considered here. The main task is so to exercise and over-develop the muscles of the upper limbs and shoulder girdle that the patient eventually can "walk on crutches" simultaneously supporting himself on his lower limbs with the knees stabilized by calipers Every patient whose lesion is below the T 1 segmental level should be able to walk again even though his paraplegia is complete The necessary exercises to over-develop the shoulder muscles are started as soon as the spinal fracture has consolidated It is astonishing how over-development of muscles such as the trapezius and latissimus dorsi (muscles supplied by cervical nerves) enables the patient to acquire the knack of tilting the pelvis so that each leg clears the ground as he walks.

Learning to walk again is, however only part of the training. Simultaneously there must be instruction in some useful and productive occupation so that when the time comes to return to the family circle the patient feels that he is a useful member of society Surprisingly enough many complete paraplegics learn to develop reflex sexual functions and achieve parenthood. All this helps to restore self-esteem and compensates for the grave disability

Spinal Cord Tumours

The term spinal cord tumour comprises a wide range of true neoplasms as well as other space-occupying lesions. They involve the spinal cord and its nerve roots either by compression or infiltration They occur at any age and the clinical picture varies according to the pathological nature of the tumour and its site.

Tumours can be divided into two main groups, according to whether they are external or internal to the dural theca, and in their turn each of these main groups may be subdivided as follows

Intradural Tumours

(1) *Intramedullary* Tumours within the spinal cord *i.e* glioma, lipoma, angioma, cholesteatoma.

(2) *Extramedullary* Tumours outside the spinal cord *i.e* neurinoma, meningioma.

Extradural Tumours

(1) *Arising from the Vertebral Column*

Primary tumours of bone, *i.e* osteoclastoma, myeloma, chondroma sarcoma.

Secondary tumours involving bone, *i.e* carcinoma of breast, prostate, lung, thyroid.

Protrusions of intervertebral discs.

Sequestrated bone and intervertebral disc fragments in Pott s disease of the spine.

(2) *Arising from the Extradural Space*

Lipoma, Hodgkin s lymphadenoma, lymphosarcoma, granuloma.

Some of these tumours are rare, but several deserve special mention. Among the latter are neurinomata and meningiomata which occur in approximately equal proportions, and which together account for 70 per cent of all spinal tumours. They resemble their counterparts in the brain, as do gliomata and cholesteatomata, but the latter account for only 10 per cent. of the total Of the remainder metastases from breast and bronchus and intervertebral disc lesions rank high.

Symptoms and Signs A detailed consideration of the symptoms and signs of spinal cord tumours properly comes within the province of a text book of medicine. However the surgeon who has to operate on these lesions must also be conversant with their recognition and symptomatology for as with brain tumours, his is the final responsibility in planning an operation.

In general, the clinical features of spinal tumours are those of nerve-root involvement, spinal cord compression or a combination of both. The striking feature of nerve root involvement is spinal pain. This pain has two main characteristics. First it is situated in part, but not necessarily in the whole of the distribution of a spinal nerve. Second it is aggravated by factors which suddenly alter the intraspinal pressure such as coughing, sneezing and straining If the nerve root involved has important motor functions, this pain is usually accompanied by weakness and wasting of the appropriate segmental muscles. Sometimes nerve root involvement can occur without spinal cord compression, as for example in cauda equina tumours and in nerve root compression near the intervertebral foramina by disc protrusions. Sciatic and brachial neuralgia are common examples of these latter conditions.

The signs of spinal cord compression are those of a steadily progressive paraplegia (or tetraplegia) referable to a segment of the cord. The motor symptoms are associated with sensory disturbances which may take several forms. It must be remembered however that this sensory loss may be dissociated, as in the Brown-Séquard syndrome Other features of spinal compression include sphincteric disturbances As a general rule with intra medullary and conus medullaris lesions incontinence of urine or retention with overflow tends to appear early while with extramedullary or extradural lesions they appear late

Diagnosis The diagnosis of a spinal cord tumour must be kept in mind whenever there are symptoms or signs suggestive of either nerve-root involvement or spinal cord compression. A thorough neurological examina tion is the first step in diagnosis and localization but it must be remembered that the level of the lesion suggested by the neurological signs may differ from the actual level by several segments. Thus the involvement of longi tudinal spinal arteries in spinal cord compression may place the upper level of sensory loss several segments above the true level of the tumour Supplementary methods of examination are required, and these are provided by (*a*) *Radiological examination of the spinal column*, (*b*) *Lumbar puncture* and Queckenstedt s test, and (*c*) Myelography

Thorough radiological examination of the appropriate region of the spinal column is essential in every case of suspected spinal cord tumour or spinal cord compression With extradural tumours, changes of a diagnostic character can usually be seen either in the vertebræ themselves or in the outlines of the intervertebral disc spaces. With intradural tumours, however

the radiological appearances may be normal or show changes which only an expert eye may detect such as widening of the spinal canal due to thinning of the vertebral pedicles Occasionally a neurinoma may be both intradural and extradural forming a dumb-bell shaped tumour with part inside the vertebral canal and part outside in the neck or thorax An enlarged intervertebral foramen may then be seen in the skiagram (Fig. 25 7)



FIG 25 7 OBLIQUE SKIAGRAM OF THE CERVICAL SPINE SHOWING THE INTERVERTEBRAL FORAMINA. THE FORAMEN BETWEEN C2 AND C3 IS GREATLY ENLARGED BECAUSE OF A DUMB-BELL SHAPED NEURINOMA.

The other special investigations lumbar puncture Queckenstedt s test and myelography (Fig. 21 15) have been discussed in Chapter 21

Treatment The operative treatment of a spinal cord tumour necessitates laminectomy It is usual to remove the spines and laminæ of three consecutive vertebra, one at the level shown by myelography and one on either side of this If the tumour is extrathecal it will probably immediately come into view An intradural tumour however is not exposed until after the dura is opened although clues as to its presence may be afforded by slight bulging of the spinal theca at this level In addition pulsation of the theca corresponding to the pulse and respiration are seen above the lesion but not below

The removal of a neurinoma or meningioma may be simple or it may be a long and tedious process, especially if the tumour is situated anterior to the cord (Figs. 25 8 and 9) As circumstances dictate it may have to be removed piecemeal but whatever the technique used the tumour should be removed in its entirety This, in the case of a meningioma will involve either removal or destruction by diathermy coagulation of the dural segment from which it arises. In the case of a neurofibroma it will involve the sacrifice of the nerve root to which it is attached



Fig. 25 8 A Neurinoma situated Posterior to the Spinal Cord



Fig. 25 9 A Meningioma situated Anterior to the Spinal Cord.
A slip of the ligamentum denticulatum has been divided and seized with forceps, thereby rotating the cord away from the tumour

Prognosis Provided the paraplegia is not absolutely complete prior to operation, the prospects of recovery of motor and sensory functions following removal of a neurinoma meningioma, or other benign tumour are good. Recovery may not be complete, but the patient is usually able to walk, while useful movements of the hands and arms return even when the spinal cord has been markedly flattened and indented by the tumour

Intervertebral Disc Lesions

Changes in the intervertebral discs due to ageing and the stress and strain of an active life are common, and in a sense they may be regarded as part of the wear and tear of life. Over the past two decades, however it has come to be realized that they may cause compression of spinal nerve roots or of the spinal cord. The pathologist Schmorl clearly showed that the initial change is usually one of desiccation of the nucleus pulposus. It may start soon after adolescence affecting certain discs but not others. Those discs which are situated in a mobile part of the spine, such as the lower lumbar region and the midcervical region are particularly liable to undergo this change, for they are most subject to repeated trauma The desiccation process gradually leads to narrowing of the disc space with the secondary changes associated with osteoarthrosis. Prominent among these osteoarthritic changes are bony lipping or ridging at the margins of the joints. During the intermediate stages of these degenerative processes, however the nucleus pulposus in part or in whole may burst posteriorly through the posterior longitudinal ligament (midline prolapse) or slightly to one side through the junction of the annulus fibrosus with the posterior longitudinal ligament (postero-lateral prolapse) This is often described as a prolapsed or protruded intervertebral disc.

Another factor associated with intervertebral disc lesions is a thickening of the ligamentum flavum at the same level This thickening is often

described as "hypertrophy of the ligamentum flavum but the histological evidence for this is poor A more likely explanation is that as the disc space narrows, the ligament relaxes and consequently bulges

Types of Prolapse Four main types of disc prolapse can be recognized and in respect of postero-lateral prolapses are depicted diagrammatically in Fig 25 10 In the first or classical type the lesion takes the form of a smooth domed and glistening projection, formed by nucleus pulposus material still covered by intact but thinned annulus fibrosus. In the second type fragments or extrusions of nuclear material of varying size actually escape into the extrathecal space through a hole in the annulus In the third type, sometimes termed a "concealed disc or "intermittent prolapse the lesion only protrudes when the disc is under strain as in weight bearing or in

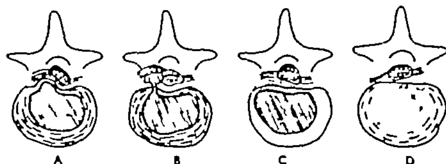


FIG. 25 10. DIAGRAMMATIC REPRESENTATION OF THE FOUR MAIN TYPES OF DISC PROLAPSE. (*Brit J Surg*)
A, Projection B, Extrusion C, Intermittent prolapse and D Scarred disc.

hyperextension. The fourth type, a "scarred disc" represents a late stage when the intervertebral disc space has collapsed and osteophytic ridges have occurred at its margins These ridges press against or become adherent to the theca and adjacent intrathecal nerve roots.

Clinical Syndromes The clinical syndromes which these lesions produce depend upon various factors, such as the level of the lesion in the spinal column, and whether it is of sufficient size to compress either the spinal cord or nerve roots. Only a brief list of the more important ones will be given here.

Posterior Crural (Sciatica) and Low Back Pain. This is often caused by a postero-lateral disc prolapse at either the L.4–5 disc space (Fig. 25 11) or the L.5–S 1 disc space compressing the L.5 nerve roots or the S 1 nerve roots as they cross these intervertebral discs. With compression of either of these nerve roots, there may be pain, weakness of ankle and toe movements, and in the case of S 1 nerve root compressions, impairment of the ankle jerk. Trauma or strain often plays a part in provoking symptoms. In most cases, symptoms will resolve with bed rest for periods of up to six weeks. It is only when symptoms are persistent, disabling or frequently recur that surgery should be contemplated. Posterior crural pain due to a disc lesion is usually accompanied or preceded by low back pain, but may occur alone. The converse is also true, and some cases of severe low back pain occurring without sciatica are due to lumbar disc prolapses.

Anterior Crural and Low Back Pain. This combination is often produced by a postero-lateral disc lesion at the L.3–4 disc space compressing the L.4

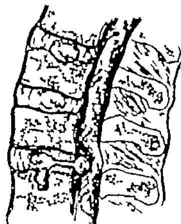


FIG 25 11 HERNIATION OF THE NUCLEUS PULPOSUS.
The protrusion is usually in the fourth or fifth lumbar disc and is placed laterally, so that the nerve root is pressed upon rather than the theca. The roots affected are commonly the fifth lumbar or first sacral.

nerve roots extrathecally This anterior crural or femoral pain may be associated with low back pain or may occur alone Slight weakness of the quadriceps femoris muscle and impairment of the knee jerk are common signs.

Cauda Equina Compression. This may result from a posterior midline protrusion generally at one of the lower three disc spaces. In partial compression numbness and irritability of the perineum and buttocks, as well as frequency or difficulty of micturition are common. In complete compression the sphincters are paralysed and the saddle area numb. A complete compression may often be preceded by bilateral "sciatica" and the final stages of compression may develop very rapidly

Cervical Spinal Root Compression. A postero-lateral disc prolapse at either the C.5–6 or C.6–7 level not infrequently leads to compression of either the C.6 or C.7 nerve roots respectively This, in its turn, produces the clinical picture of brachial neuralgia, characterized by pain extending the length of the limb in the distribution of the affected nerve root, and aggravated by coughing, sneezing and by movements of the neck Often there are associated neurological signs such as slight weakness of the triceps muscle, and impairment of the triceps jerk As in sciatica so in many cases of brachial neuralgia due to disc prolapse the symptoms are provoked by trauma or strain

Spinal Cord Compression by Disc Prolapse. This syndrome is much less frequent than the others, but sometimes a midline posterior prolapse of the nucleus pulposus, in either the thoracic or cervical region may be of sufficient size to produce the clinical picture of spinal cord compression indistinguishable except on radiological examination (myelography) from that produced by *other types of extramedullary spinal cord tumours.* Some of these disc prolapses were described in the older literature as chondromas of the inter vertebral discs The clinical picture may be rapid or gradual in its evolution, and occasionally the picture of a complete paraplegia results. In only some of these cases of spinal cord compression is there a history of antecedent injury or strain.

Spinal Cord Compression by Cervical Spondylosis. This is of more

common occurrence and it is becoming increasingly realized that many cases of chronic progressive paraplegia ocurring in middle-aged and elderly persons are due to pressure exerted against the anterior aspect of the spinal cord by bony ridges projecting backwards from the margins of one or more degenerated cervical intervertebral discs. The disc spaces most affected are between C.4 and C.6 Sensory disturbances are often inconspicuous, and some cases in the past have been mistakenly labelled amyotrophic lateral sclerosis.

Diagnosis and Treatment The diagnosis and the treatment of these various syndromes is a joint responsibility between physician, radiologist



FIG. 25 12. MYELOGRAM SHOWING LATERAL INDENTATION OF THE FOURTH LUMBAR INTERVERTEBRAL DISC SPACE CAUSED BY A DISC PROLAPSE.

and surgeon. When operation is indicated this is undertaken in some centres by neurosurgeons and in others by orthopædic surgeons. It must be realized, however that there are other causes of nerve root and spinal cord compression besides disc lesions. Therefore great care should be taken in the neurological examination and myelography used for precise diagnosis (Fig. 25 12) In cases when only nerve roots are compressed, as for example, in sciatica, anterior crural neuralgia and brachial neuralgia, a period of immobilization of the spine by bed rest for up to four to six weeks is desirable in the first instance Most patients so treated recover without operation it is only when the symptoms are persistent, disabling, intractable, or re current that operation should be considered. In the milder cases various physiotherapeutic measures and a light spinal support are often effective. Manipulation of the spine is practised by some and often with success, but

most neurosurgeons have encountered cases which were seriously aggravated by such therapy or even showed spinal cord compression

Most neurosurgeons agree that early operation is indicated if there are signs of cauda equina or spinal cord involvement by a "soft" nuclear prolapse, for a sudden increase in prolapse may cause irretrievable paralysis. Operation for this condition and nerve-root compression is laminectomy with exposure of the prolapse. Removal of the projecting part of the prolapse is not adequate the whole soft interior of the intervertebral disc must be removed to prevent recurrence. To this end, it is often desirable to approach and curette the disc from both sides of the theca. A limited operative approach removing only the ligamentum flavum and a tiny portion of the adjacent lamina has been advocated by some The exposure so obtained is often inadequate and full laminectomy is usually preferable.

The treatment of cervical cord compression due to bony ridges in cervical spondylosis is different. Attempts at removing the bony ridges often result in inflicting greater damage to the cord. If surgical treatment is decided on a decompressive laminectomy of several vertebræ is usually all that is advisable. This may include section of several slips of the ligamentum denticulatum on both sides to facilitate shifting the cord back a little from the disc ridge. Many patients so treated subsequently show distinct clinical improvement.

Chapter 26

THE SURGICAL RELIEF OF INTRACTABLE PAIN

Introduction

The ideal treatment of any painful condition is the eradication of its cause. Thus the pain associated with dental caries, peptic ulceration, fissure-in ano and sciatica due to prolapsed intervertebral disc is usually relieved by measures directed at the underlying lesion Sometimes this is not possible, either because the cause cannot be removed or relieved, or because it is still unknown. Examples where the cause cannot be dealt with are infiltration of nerve trunks or plexuses by malignant neoplastic disease, irremovable fibrosis and lesions affecting the pain pathways in the central nervous system, such as syringomyelia, post herpetic neuralgia, tabes dorsalis and " thalamic syndromes." Examples of severe pain of unknown ætiology are tic douloureux, causalgia and certain phantom limbs. Some of the more important of these conditions are described below together with their appropriate treatment.

Pain Affecting the Limbs and Trunk

Intractable Pain due to Malignant Disease. One of the commonest of the intractable pain syndromes is that resulting from infiltration of the brachial plexus by malignant deposits. In like manner intercostal nerves may be involved by a bronchial carcinoma and the sacro-iliac plexus as a result of carcinoma of the cervix uteri or rectum Characteristically the pain is continuous by day and by night, of a neuralgic character and situated in the territory of distribution of the affected nerves. It is often accompanied by appropriate neurological signs. Often the pain persists in spite of X ray therapy indeed the fibrosis resulting from such treatment may exacerbate the pain In the later stages the patient may be cachectic.

Intractable Pain resulting from Trauma. A whole range of painful syndromes is included here. In the intact limb there occur major and minor causalgias and post-traumatic painful dystrophies. Classical major causalgia is uncommon it results from injuries affecting the median, ulnar and sciatic nerves. It is characterized by continuous burning pain in the distal part of the extremity wasting of the palm, foot or digits and erythema and sweating in the affected area. The pain spreads beyond the area of distribution of the injured nerve and the patient keeps the affected limb immobile and often protects it with a cool damp covering. The minor causalgias are similar in character but less severe and often aching rather than burning in character They may result from injuries to quite small nerves, such as the digital. The post traumatic painful dystrophies, *e g* Sudeck's bony atrophy frequently result from crush injuries to the distal part of a limb. They are

characterized by pain of minor causalgic type related to a joint together with osteoporosis of the adjoining bones.

Intractable pain may also occur after amputations. Painful neuromas should be suspected first, but the mechanism of pain is not understood, for although there may be several neuromas in the amputation stump, often only one is painful The neuroma may be tender only on direct pressure or it may be associated with a continuous neuralgic or even causalgic pain in the stump The symptoms of a tender neuroma may be relieved by excising it, but a causalgic spread of pain from a neuroma usually persists after its removal and even after re-amputation at a higher level.

The pains associated with phantom limbs are very intriguing. After amputation every patient has a sense that the missing limb is still present. Generally he feels that only parts of the missing limb are there, such as the digits, palm, wrist or heel The phantom itself is usually painless, but some times irritable sensations are experienced in it these are seldom troublesome. Very occasionally however the missing limb may be the seat of severe cramping pain often aching, sometimes even burning, without there being any corresponding pain in the stump itself Such patients in the past have often been regarded as hysterical, but those who have to deal with many of them point out that the pain conforms to a recognizable and therefore presumably organic pattern.

Pain Affecting the Head

Tic Douloureux. This is probably the most frequent painful syndrome in the head which a surgeon is asked to treat. It takes one of two forms the first of these, idiopathic trigeminal neuralgia, is common the second idiopathic glossopharyngeal neuralgia is rare

Trigeminal Neuralgia This is characterized by bouts of sharp lancinating pain occurring generally in the territory of the face or buccal cavity supplied by either the second or third division of the trigeminal nerve. Only occasionally does it occur in the territory of the first division The pain is aggravated or provoked by any stimulus to the skin of the affected division, such as occurs in eating, talking, or touching the face. There is no accompanying sensory loss

Glossopharyngeal Neuralgia The pain of this is similar to that of trigeminal neuralgia, but limited to the faucial and tonsillar region

Intractable Pain Due to Malignant Disease. This is similar to the corresponding syndromes affecting the limbs or trunk and usually results from cancer arising in the buccal cavity nasopharynx or antrum and spreading to involve nerve trunks. The resulting pain may therefore extend into the territory not only of the trigeminal nerve, but also of the glossopharyngeal and upper cervical nerves

Pain arising from Lesions within the Central Nervous System

These are mentioned to complete the clinical picture of intractable pain and include such conditions as painful hemiplegia, post hepatic neuralgia, tabes dorsalis and syringomyelia Persistent pain may occasionally follow small penetrating injuries in the parietal cortex. Consideration of these various conditions, however is outside the scope of a surgical text book.

Principles underlying the Surgical Relief of Intractable Pain

The surgeon's first duty is to decide whether the patient's pain is genuine and whether its severity and intractability warrant surgical intervention. It is helpful if the pain can be identified as fitting into one of the recognized organic categories. In cases of doubt the surgeon should seek the aid of his neurological and psychiatric colleagues. It is unwise to operate on pain of psychiatric origin. When the pain constitutes only a slight disability or one which can be relieved by mild analgesic drugs, surgery is contra-indicated.

The principle underlying the surgical relief of intractable pain is section of the pain pathways in the nervous system at a level which will prevent painful impulses from reaching the sensorium. Only if this is not practicable is it justifiable to perform frontal leucotomy in order to modify the patient's appreciation of pain. A knowledge of the principal pain pathways is therefore essential, for section of these pathways at some levels may be accompanied by disturbing side effects.

Anatomy of Pain Pathways. *The Trunk and Limbs.* Pain impulses from the trunk and limbs are conveyed to the sensorium by three relays of nerve fibres. The first relay is made up of the axons of cells in the dorsal root ganglia of the spinal nerves. These axons include fibres which have ascended from the somatic peripheral nerves as well as fibres from the sympathetic nervous system arriving *via* the white rami communicantes. Within the dorsal nerve roots, pain fibres are mixed with fibres conveying other forms of sensation. However, within the spinal cord the various sensory fibres separate according to their modality and the fibres conveying pain and temperature terminate almost immediately around the nerve cells in the dorsal gray matter (substantia gelatinosa of Roland). The axons of these cells form the second pain relay; they quickly cross over to the antero-lateral white matter of the other side of the cord, and there ascend in the lateral spinothalamic tract to the nucleus ventralis posterior of the thalamus. Here are situated the cells of the third relay whose axons pass on upwards to the cortex. The primary sensory cortical area is the post-central gyrus, and it is presumably here that many sensory impulses enter into consciousness. There are in addition other sensory receiving areas, notably the secondary sensory cortical area situated along the upper bank of the posterior limb of the Sylvian fissure. This area receives sensory impulses from both sides of the body. For many decades it has been taught that pain of a crude, poorly localized, spreading and often burning character enters consciousness within the thalamus, but modern neurophysiological work gives no firm support to this view. However, pain of this character is often still referred to as "thalamic pain" although in point of interest such pain can arise from lesions at any level of the nervous system, even from lesions of the peripheral nerves.

The Head. Pain impulses from the head are similarly conveyed by three axonal chains. Pain impulses from the face, anterior two-thirds of the tongue, and anterior buccal cavity are collected together in the trigeminal nerve, the afferent axons of which have their cell-station in the Gasserian ganglion. The glossopharyngeal nerve similarly conveys pain impulses from the posterior third of the tongue and from the faucal region, while the vagus nerve conveys impulses from the external auditory meatus, concha of the ear and larynx. Within the brain stem, pain fibres from all these nerves become separated from touch fibres and are collected together into the

descending tract of the trigeminal nerve. The axons of the cells of the nucleus of the descending tract then form the second pain relay and cross over in the brain stem to ascend to the nucleus ventralis posterior of the thalamus. The axons of cells in this nucleus supply the third link to the *cerebral cortex*.

Operations for Intractable Pain in the Limbs or Trunk. A variety of procedures is available among which may be listed section of somatic nerves (peripheral neurectomy) section of sympathetic pathways (sympathectomy), section of posterior nerve roots (posterior rhizotomy), alcohol injection of the cauda equina, and antero-lateral cordotomy The merits and demerits of the various procedures will be briefly considered

Peripheral Neurectomy As section of most somatic nerves will result in both motor and sensory paralysis, peripheral neurectomy is limited in its applicability to nerves that are purely sensory or whose motor functions do not matter Instances are the resection of painful neuromas in amputation stumps and of intercostal nerves involved in scar or malignant tissue. Prior to operation the likely effect of any such nerve section can be judged by blocking the nerve with a local analgesia solution.

Sympathectomy Sympathectomy has its greatest rôle in the treatment of major and minor causalgias, post traumatic dystrophies and causalgic painful amputation stumps. Prior to operation an infiltration with a local analgesic solution of the appropriate part of the gangliontated sympathetic chain (either upper thoracic or lumbar) should be carried out as a *diagnostic* test. Sometimes the block will itself be followed by disappearance of the pain for days, weeks, months or even longer in such instances a test performed initially for diagnosis can be repeated at intervals for its therapeutic effect. Sympathectomy at the appropriate level is also of value in relieving pain of visceral origin. Thus an upper thoracic or stellate ganglionectomy may confer benefit in severe angina pectoris, while a presacral neurectomy may relieve intractable dysmenorrhœa

Posterior Rhizotomy As a method of relieving pain posterior rhizotomy has the limitation that *it affects all modalities of sensation*, and *also* that in order to be effective a minimum of three successive nerve roots have to be divided (the nerve-root or roots directly involved plus the nerve-roots immediately above and immediately below) Posterior rhizotomy therefore cannot be applied to the treatment of diffuse pain in a limb, because the complete sensory denervation which follows section of several successive nerve-roots would render the limb useless. Even an amputation stump would be hampered if a prosthesis were to be used. Further posterior rhizotomy will not relieve the pain of causalgia, of painful phantom limbs, or of postherpetic neuralgia. In practice its value *is largely limited to the* relief of segmental pain involving the trunk (as for instance when intercostal nerves are invaded by scar tissue or by malignant disease), when the resulting sensory loss is of little account.

Alcohol Injection of the Cauda Equina. This method results in a chemically-produced posterior rhizotomy It is difficult to control precisely therefore it is applicable only for the relief of pain in a lower limb when the expectation of life is very short (as for instance in the terminal stages of a carcinomatous process involving the sacro-iliac plexus) The procedure is *carried out by performing a* lumbar puncture with the patient on his side, so postured that the affected leg is uppermost and the lumbosacral region elevated slightly above the rest of the spine Between 0 75 and 1 ml. of

absolute alcohol is injected through the lumbar puncture needle, which is then withdrawn The alcohol, being of lighter density than cerebrospinal fluid rises to the highest point of the thecal column where it bathes the lower lumbar and upper sacral nerve-roots, both anterior and posterior supplying the affected lower limb. The results are somewhat capricious and unpredictable Generally a satisfactory sensory loss is produced in the affected lower limb but with relative sparing of its motor functions. Sometimes the loss is too extensive, other times insufficient Sphincteric functions may at times be disturbed For these reasons the procedure is inadvisable for any patient who is still active on his feet, or who has a life expectancy of more than three months (an antero-lateral upper thoracic cordotomy is preferable in these circumstances) It is, however worth trying in a patient who is already bedridden

Antero-lateral Cordotomy This ranks first in usefulness among the various procedures available for relieving pain from the limbs and trunk.

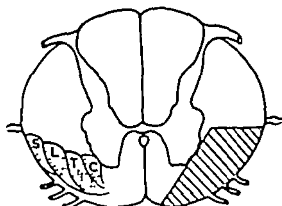


Fig 26 1 Diagrammatic Transection of the Upper Cervical Spinal Cord

On the left immediately in front of the plane of the ligamentum denticulatum is the position of the pain-carrying fibres in the lateral spinothalamic tract with their arrangement into sacral, lumbar thoracic and cervical segments. On the right is marked the extent of the incision in a high cervical cordotomy

It produces loss of sensation only for pain and heat, sparing touch and posture. The patient is often aware of scarcely any alteration in body sensation, except when he puts his leg into a bath and finds he cannot tell the temperature of the water

The anatomical basis of the operation is that it interrupts the lateral spinothalamic tract. Consequently it has to be performed on that side of the cord opposite to the side of the body which is to be denervated For pain below the nipple line the operation is usually performed at either the T 1 or T.2 level of the cord, because at this level the spinothalamic tract is usually better defined than lower down, while at the same time the section avoids the cervical enlargement of the cord. Under general anæsthesia or local analgesia, the cordotomy knife is inserted transversely into the cord to a depth of 3–4 mm. immediately in front of the line of the ligamentum denticulatum. It is then directed forwards so that its point emerges on the surface of the cord 2 or 3 mm. in front of the line of the anterior roots (Fig. 26 1). Subsequently pain and thermal sensibility are usually found to be completely abolished down the opposite side of the body below the xiphisternum

In painful conditions of the upper limb or thorax, high cervical cordotomy is necessary. The incision is usually made in similar fashion between the points of emergence of the C.1 and C.2 nerves, but to a depth of 5-6 mm. The operation should always be performed under local analgesia, so that the level of sensory loss produced can be tested, and the incision in the cord deepened or extended as required. It is thus possible to produce a level of analgesia as high as C.4 or C.5 dermatomal levels.

Antero-lateral cordotomy is of value not only for most cases where nerve trunks are involved in scarred or malignant tissue but also for many cases of causalgia, painful phantom limbs and painful amputation stumps which do not respond to posterior rhizotomy. A major difficulty however is to produce a permanent level of complete analgesia. In many cases, possibly as high as 20 per cent., some pain sensibility returns after several months, leading either to reappearance of the original pain or the appearance of perverted sensations in the lower part of the body. This return of pain sensibility can occur even when the antero-lateral column has been adequately sectioned, and is probably due to anomalies of distribution of the pain-carrying fibres in the cord. While it may not matter much for a patient with limited expectation of life, as in pain due to carcinoma, it constitutes a more serious hazard in benign lesions such as chronic arthritis of the hip. In operating on such patients a small proportion of failures must be expected. Such, however, is the limited choice of procedures open to the surgeon, that he may sometimes have to take this risk.

Other Procedures. Attempts have been made to interrupt the pain pathways at even higher levels in the central nervous system, but none of these procedures have as yet gained acceptance. The division of the spinothalamic tract in the medulla or midbrain is technically difficult and the resulting analgesia disappointing. Diathermy coagulation by stereotactic means of the nucleus ventralis posterior of the thalamus is now under trial, but the permanence of this procedure has yet to be evaluated. Excision of the appropriate part of the post-central gyrus (post-central gyrectomy) has been tried by a few surgeons for intractable pain in a limb (including phantom limbs), but while it may give relief for some time, recurrence of pain is usual after several months.

Operations for Intractable Pain in the Head. The operative procedures available for the limbs and trunk have their counterparts for the head.

Cranial Neurectomy. Section of peripheral branches of cranial nerves can be undertaken. The nerves principally concerned are the trigeminal and the glossopharyngeal. Avulsion of the infra-orbital branch of the trigeminal nerve or of the supratrochlear and supra-orbital branches is sometimes performed in frail elderly patients for tic douloureux. However, in more active subjects, subtotal section of the sensory root of the Gasserian ganglion is preferable because the pain frequently spreads beyond such limited nerve distributions. For glossopharyngeal neuralgia the glossopharyngeal nerve can be readily divided by an approach through the tonsillar fossa as an alternative to the neurosurgical approach through the posterior fossa.

Sensory Root Section. Section of the sensory root of a cranial nerve is analogous to posterior rhizotomy of a spinal nerve. Section of the outer and lower three-quarters or four fifths of the sensory root of the Gasserian ganglion is the standard neurosurgical procedure for the common form of trigeminal neuralgia which involves the second or third division of the nerve

(Figs. 26 2 and 3) The sparing of the upper quarter or fifth of the nerve preserves sensibility in the forehead and cornea, so obviating the risk of a neuropathic keratitis. It is also usually possible to spare the motor root and so avoid a masticatory paralysis. The operation is generally carried out by the classical approach of Frazier through a small opening in the skull made low in the temporal fossa. The Gasserian ganglion is then exposed by elevating the dura off the floor of the middle cranial fossa after coagulating and dividing the middle meningeal artery at the foramen spinosum. This extradural approach however is sometimes complicated by a facial palsy (due to traction on the great superficial petrosal nerve). Consequently some surgeons now modify the procedure by incising the dura after they have made their bony opening, thus approaching the Gasserian ganglion intradurally.

Trigeminal neuralgia seldom involves the first division of the nerve.

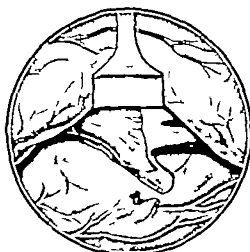


FIG. 26 2. EXPOSURE OF THE GASSERIAN GANGLION.

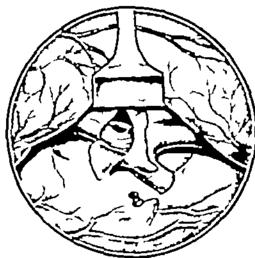


FIG. 26 3 RETRACTION OF THE SENSORY ROOT TO REVEAL THE MOTOR ROOT OF THE FIFTH NERVE.

When it does so some surgeons still perform total section of the sensory root, while others resort to alcohol injection of the Gasserian ganglion which has much the same effect but is simpler to perform. Both sets of procedures, however completely denervate the cornea, and so expose the patient to the risks of a keratitis. It is preferable in such cases to perform an intramedullary tractotomy

Sometimes the surgeon is called upon to relieve pain involving not only the trigeminal territory but also the glossopharyngeal and upper cervical nerves as well. An instance is pain associated with carcinoma of the floor of the mouth. In such cases a subtotal section of the sensory root of the Gasserian ganglion can be combined with an intracranial section of the glossopharyngeal nerve and with posterior rhizotomy of the upper three cervical nerves.

Injection of the Gasserian Ganglion Injection of the peripheral branches of the trigeminal nerve with 90 per cent. alcohol is often performed for tic douloureux affecting their territories. Thus the third division may be injected at the foramen ovale, the infra-orbital nerve in its canal, and the second division in the sphenomaxillary fossa. The injections are carried out under local analgesia by techniques usually described in operative surgical hand

books. The numbness produced by these injections persists for only three to nine months, and with the return of cutaneous sensibility recrudescence of pain is likely. However, such injections are frequently employed as the first stage in treatment, both as a preliminary therapeutic test and also to condition the patient to experiencing numbness of the face. For once their old pain is forgotten, a few patients (possibly up to 5 per cent.) complain bitterly of the insensibility of their face (whether brought about by operation or injection) and in them injection is preferable to operation.

In contrast, alcohol injection of the Gasserian ganglion itself usually produces permanent numbness and consequently permanent relief of pain. However, if the cornea is also denervated, as usually happens, there is an ever present risk of neuropathic keratitis. Certainly this risk can be obviated by prescribing closely fitting goggles whenever the patient goes out of doors. If keratitis should supervene, it can be relieved by a partial lateral tarsorrhaphy. Consequently, considering the relative ease of the procedure, it is not surprising that alcohol injection of the ganglion is widely practised.

Intramedullary Trigeminal Tractotomy. Section of the descending tract of the trigeminal nerve within the medulla leads to loss of pain and thermal sensibility on the same side of the face but spares touch. As an operative procedure it is technically more difficult than either alcohol injection of the ganglion or section of the sensory root, but in competent hands its results in cases of tic douloureux involving the first division of the nerve are superior to those of the other two procedures. This is because with the sparing of tactile sensibility the corneal reflex, although often diminished, is retained, and the risk of neuropathic keratitis obviated. The other chief indication for the operation is when tic douloureux appears in the second side of the face, and the first side has already been denervated by operation or alcohol injection. An intramedullary tractotomy in such circumstances avoids complete denervation of both sides of the mouth and lower jaw with consequent serious difficulties in eating.

Prefrontal Operations for Intractable Pain. If pain is severe, disabling and intractable, and if it cannot be relieved by any more direct surgical approach (such as antero-lateral chordotomy), the operation of prefrontal leucotomy should be considered. Alternatively one of its more recent modifications may be used, such as bimedial leucotomy, rostral leucotomy or orbital undercutting. Instances of such pain are few, but they include the pain of the various " thalamic " syndromes arising within the central nervous system (including postherpetic neuralgia) and extensive malignant disease involving the head and neck, regions too extensive in practice for denervations of the ordinary sort.

The general experience after these prefrontal operations is that the patient will still experience pain, but will not worry about it nor let it disturb him as formerly. In other words the patient's reactions to pain are blunted. There is also some blunting of the patient's emotional reactions, with less worry about ordinary private affairs and relationships with other members of the family. Consequently an operation, which to the surgeon may have achieved its primary objective of relieving the patient's fears and anxieties, may yet fail to satisfy the patient's friends and family. The patient's psychological background, and the likely merits and demerits of the operation should be carefully weighed under the guidance of an expert psychiatrist before such an operation is undertaken.

Section Four

THE SURGERY OF THE HEAD AND NECK

L H SAVIN SIR VICTOR NEGUS
MICHAEL HARMER

Chapter 27

THE SURGERY OF THE EYE

Introduction

The subject of ophthalmology is so vast that a general survey even of its surgical aspects in one chapter would lead to an unintelligible degree of compression. It is preferable to deal in some detail with certain typical subjects such as the surgery of cataract, methods of local analgesia injuries, and the differential diagnosis of some of the commoner affections

Examination of the Eyes

This is best done systematically in the following sequence

(1) **General Inspection.** Any difference between the two sides, such as differences in width of the palpebral fissures, irregularities of the orbital margins, degrees of proptosis—if any—redness of the eyes lacrimation differences in colour of the irides, should be recorded



FIG. 27 1 IRREGULARITIES OF THE PUPIL.

1 Iridodialysis the ciliary processes and lens border and suspensory ligament are exposed. 2, Congenital coloboma. 3 Persistent pupillary membrane. 4 Results of iritis posterior synechiæ, uveal pigment on lens capsule the pupil is dilated as much as possible by atropine.

(2) **The Pupils.** Irregularities of shape or size should be noted. The eyes should next be shaded by the observer's hands in such a way as to leave the pupils still visible If the hands are removed one at a time it is possible to note the reaction of the pupil on one side to light, while at the same time observing whether there is a consensual reaction of the other pupil The pupillary reactions to convergence should be tested by holding the observer's finger about 2 feet from the patient's nose, while instructing the patient to look at the finger The finger is then brought rapidly towards the patient's nose and the reactions of his pupils to this rapid convergence are noted.

(3) **Tension.** The patient is made to look down, while a digital estimation of the tension is made The observer's forefingers are approximated together the tips palpating the eyeball through the upper lid. The globe is then gently fixed by one forefinger while the other indents it, so that the resistance to indentation or "tension" can be estimated This gives an indication of

the intra-ocular pressure. Knowledge of normality is attained by practice. Standard clinical notation describes the eye as having a tension of normal, +1 +2 or +3 degrees of increasing order of hardness. Conversely hypotony is described as showing, —1 —2, —3 degrees of subnormal tension.

The tension may be measured mechanically by a *tonometer* calibrated to correspond with mm Hg. of intra-ocular pressure. The eye is anæsthetized by a drop of 1 per cent. Holocaine. The principle of a tonometer is to let a small weight of known size rest on the cornea, the patient being in a supine position The indentation of the eye is magnified by a series of levers, ending in a pointer to a small scale from which the "intra-ocular pressure" can be found. *Tonometers are useful clinical instruments but owing to* lack of adequate standardization, differing figures are often given by different machines. The reading for normality lies between 20 and 30 mm. Hg.

(4) **Ocular Movements.** The patient is made to watch the observer's forefinger which is made to move laterally up and down, and in oblique meridians This allows observation of limitation of ocular movements. Lateral movements are controlled by the external rectus (supplied by the sixth nerve) and internal rectus (third nerve) An eye is mainly moved upwards by the superior rectus (third nerve) when turned outwards, or inferior oblique (third nerve) when looking nasally The eye is mainly moved downwards by the inferior rectus (third nerve) when turned outwards, and by the superior oblique (fourth nerve) when turned nasally The muscles have subsidiary actions of torsion of the eye but for most purposes these may be neglected by elementary students

If the eyes have good vision, paralysis of one muscle will cause diplopia, or "double vision, the image in the paralysed eye being known as the "false image" while the image in the non paralysed eye is the "true image." *If the eyes are in a position of rest, the "true image" seems to coincide* with the true position of the object, while the "false image" is displaced from it in the direction in which the globe would normally be drawn by the paralysed muscle. If the eyes are moved in the direction of action of the paralysed muscle the apparent distance between "true" and "false" images increases, the latter being the farther displaced. Conversely "true" and false" images tend to coincide if the eyes are moved the reverse way If the unparalysed eye fixes, the deviation of the other eye is known as the "primary deviation." If the paralysed eye is made to fix an object, the deviation of the unparalysed eye is described as the "secondary deviation." In cases of paralysis of an ocular muscle, the "secondary deviation" is always greater than the primary deviation" of the eyes.

(5) **Visual Fields.** If the observer's own visual fields are normal, he can form an approximate estimate of the patient's visual *fields by the confrontation method* The two face each other testing first the patient's right visual field, then his left. To test the right field the patient is made to cover the left eye with his hand while conversely the observer covers his own right eye *They each utilize the other's eye as the fixation point,* while small white objects are moved towards the fixation point from the periphery until they come into view Comparisons can thus be made between the visual fields of patient and observer If necessary permanent records of visual field can be made on a *perimeter* working on the same principle

The central visual field and the "blind spot" (corresponding to the projection in space of the area occupied by the optic disc) are usually mapped

out on a flat *Bjerrum's screen* at 2 metres distance using graduated white and coloured test-objects

(6) **Visual Acuity** This is tested by making the patient read at 6 metres range a series of letters of graded diminishing sizes on the *Snellen's distance test types* Visual acuity is written in the form of a fraction e g visual acuity of 6/18 means that at a distance of 6 metres the eye can only observe a letter which a normal eye could see at 18 metres For accurate comparisons of visual acuity any errors of refraction should be corrected by appropriate spectacles.

The *Jaeger reading types* consist of paragraphs of print of graded sizes of type for the purpose of testing visual acuity for reading purposes



FIG. 27 2. A MECHANICAL SELF-REGISTERING PERIMETER BY WHICH THE VISUAL FIELD CAN BE ENTERED ON A CHART

The Faculty of Ophthalmologists has recently issued an improved form of reading test types.

Colour vision is usually tested by means of the Ishihara charts on which dotted outlines of figures are printed in colours unrecognizable by red-green colour blind persons. The backgrounds of the charts are made up of similarly shaped dots in neutral colours. The Board of Trade lantern test depends on the recognition of a series of lights of equal luminosity and of a colour actually employed at sea. Another test depends on the recognition of colour in a spectroscope in which any part of the spectrum can be isolated by shutters. Tests in which different coloured wools are matched are found in practice unreliable, and are largely superseded.

(7) **Conjunctiva and Lacrimal Passages.** Pressure is made by the finger-tip over the internal tarsal ligament. If pus regurgitates from the puncta lacrimalia infection of the lacrimal passage is demonstrated. The patency

of the nasolacrimal duct may where necessary be tested by syringing, as later described

The lower conjunctival fornix is inspected after pulling down the lower lid. The inner surface of the upper lid is next inspected For this purpose it is advisable for the student to learn the small manœuvre of *everting the upper lid.* This should be practised frequently until it can be performed gently and almost automatically Using the forefinger and thumb of the left hand the observer gently seizes the lashes of the upper lid. The lid margin is very carefully pulled forward away from the eyeball. The observer then places his right forefinger on the skin of the upper lid about a centimetre from the margin The right forefinger is then depressed while the lashes are lifted by the finger and thumb, when the lid will be found to evert itself so that its under surface is available for inspection.

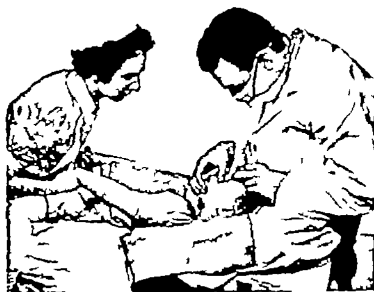


FIG. 27 3 EXAMINING A DIFFICULT CHILD.

Examination of Resistant Children Most children are remarkably sensible patients, who may be examined in the same way as adults Occasionally a child will not respond to reason and an anesthetic scarcely seems justified In such cases the mother is made to sit down with the child on her lap facing her with legs astride The examiner sits behind the child, facing the mother with a towel across his lap The child is then lowered, see-saw style, so that its head is gently grasped between the examiner's knees while the mother holds its hands. The eyes may now be examined with little difficulty and with much less disturbance to the child than if he had been allowed to struggle

(8) **Ophthalmoscopy** The surgeon finally examines the eye with the ophthalmoscope. Opacities are noted and it is decided whether they move independently of the eye as in the aqueous or vitreous, or whether they are in one of the fixed media such as lens or cornea. The position is often best determined by making use of the phenomenon of parallax, judging the position of the opacity in relation to such fixed points as the pupillary margin,

or the reflection of a light on the cornea which reflection appears to be situated in the posterior lens cortex

Afterwards the fundus oculi is carefully examined note being taken of the condition of the disc, vessels macula lutea and fundus background Certain ophthalmoscopic appearances of surgical importance are described on page 685

Other special examinations may include retinoscopy and refraction examination by oblique illumination and corneal loupe scotometry, and the use of the slit lamp These procedures are best learned under direct tuition

Anæsthesia in Ophthalmology

In former years practically all ophthalmic operations were done under local analgesia. This was because of traditional surgical techniques requiring the co-operation of the patient and because of the dangers of post anæsthetic restlessness and vomiting, which might cause injury to eyes upon which operations had recently been performed Modern methods of anæsthesia are becoming more extensively employed in ophthalmology but for many operations it is still necessary to use the following methods

(1) **Anæsthesia by Drops.** Moderately good superficial anæsthesia can be obtained by instilling into the conjunctival sac three or four drops of sterile 2 per cent. cocaine solution More profound anæsthesia can be obtained by the use of 4 per cent. cocaine solution. This is usually adequate for such procedures as the removal of a corneal foreign body but supplementary methods are required for intra-ocular operations Cocaine, in excess, has the disadvantage of causing some roughening and desiccation of the corneal epithelium This drawback is not shared by several cocaine substitutes such as pantocaine, Holocaine or Decicain in 1 per cent. solution but all these drugs cause considerable conjunctival hyperæmia

(2) **Subcutaneous Injections.** These are used in many small operations on the lids and conjunctivæ Procaine may be employed in 2 per cent solution or in 5 per cent. solution where a large bulk of injection fluid is inconvenient Another useful injection fluid is lignocaine (Xylocaine) hydrochloride in 2 per cent. solution which may also be employed in regional analgesia

(3) **Regional Analgesia.** Injections of procaine 5 per cent. or 2 per cent. solution may be used to block sensory or motor nerve impulses The following injections are those most commonly performed

Ciliary Ganglion Block This lies at the back of the orbit on the outer side of the optic nerve. In order to surround it with procaine the lower and outer angle of the orbital opening is palpated The hypodermic needle is then inserted just inside the orbital margin and passed backwards for 2 5 cm towards the opposite mastoid process, after which the piston of the syringe is withdrawn gently in case the needle is in a vein If not an injection of 1 ml. of procaine is slowly given. This injection blocks many of the sensory impulses from the eyeball, and is an excellent adjuvant to surface analgesia by drops It has the disadvantage of sometimes lowering the intra-ocular pressure. If the injection spreads inside the muscle cone the movements of the inferior rectus may be blocked, so that the patient cannot co-operate by looking down.

Nasociliary Nerve Block This is blocked by an injection an inch back into

the orbit at its upper and inner angle. Care must be taken not to inject the procaine intravenously A successful block of this nerve renders the cornea analgesic and in conjunction with the blocking of the ciliary ganglion it gives adequate analgesia for removal of the eyeball if desired. The infratrochlear branch of the nerve supplies the lacrimal sac.

Infra-orbital Nerve Block This has terminal branches which supply the lower lid side of nose and upper lid Inside the infra-orbital canal are given off the anterior superior dental branches to the upper incisors and canines, also to the bony nasolacrimal canal. The nerve may be blocked either posteriorly at the foramen rotundum, anteriorly in the infra-orbital canal, *or after its exit from the infra-orbital foramen* In ophthalmic surgery the nerve is usually blocked at its anterior end The surgeon first finds by palpation the supra-orbital notch, from which he judges where a vertical line in the sagittal plane would intersect the lower orbital margin. The infra orbital foramen may be found on the anterior surface of the superior maxilla *a short distance below the orbital margin If it is desired to block the* anterior superior dental nerve, the point of the hypodermic needle is gently manipulated till it engages in the foramen. The needle may then be passed back wards and outwards along the infra-orbital canal for about 1 cm., when procaine is injected.

(4) **Akinesia.** This is *a term applied to prevention of movement in* a muscle by the local injection of procaine or other blocking solution of local anæsthetic. In ophthalmic surgery akinesia is mostly required for prevention of spasm of the orbicularis oculi muscle.

Van Lint Rochat Method Here procaine is injected into the orbicularis muscle at the outer canthus and along the outer part of the upper and lower orbital margins This procedure considerably lessens orbicularis spasm.

Superior Rectus Infiltration One of the difficulties sometimes encountered in ophthalmic operations is the primitive defence reflex which causes the patient to roll his eye upwards, usually forcibly closing the lids at the same time This ocular movement is well seen in " Bell's phenomenon " where a patient with facial paralysis tries to shut his eye This movement may be prevented by injecting procaine into the superior rectus muscle through the upper conjunctival fornix, or alternatively the hypodermic needle may be entered at the middle of the upper orbital margin and passed backward for an inch along the roof of the orbit before the injection.

(5) **O Brien Facial Block.** The orbicularis oculi muscle is supplied by the upper division of the facial nerve. This nerve leaves the skull at the stylomastoid foramen and winds round the outer side of the condyle of the mandible on its way to the muscle. If it is desired to block the nerve, the surgeon feels the condyle of the jaw in front of the patient s ear The patient is then made to open his mouth widely and the condyle is felt to slip forwards. An assistant fixes the jaw to prevent its closure by a finger on the symphysis menti. The surgeon then injects 1 ml of 5 per cent procaine on to the condyle of the jaw an additional 1 ml. in the superficial tissues, and a few drops of procaine solution subcutaneously into the anterior surface of the upper lid. This will put the orbicularis out of action for the period of the operation. Afterwards the lids can be closed by a silk stitch through the anæsthetized area of upper lid skin the free ends being fastened by strapping to the skin of the cheek. In a few hours the muscle will have recovered its tonus and the stitch can be removed

Cataract

Definition. In medical terminology this term is applied to any opacity of the crystalline lens of the eye Since the advent of the slit-lamp lens opacities have been extensively studied and classified anatomically morphologically and according to their supposed aetiology Details may be sought in special works on ophthalmology

When speaking to patients the term " cataract " should be reserved for such cases as seem likely to require surgery as otherwise much unnecessary alarm will be caused To the lay mind the term has acquired a rather ominous significance almost comparable to such terms as " tuberculosis " or " cancer " It is not generally realized that a high proportion of elderly people have a few lens opacities which may cause little or no trouble



FIG 27 4 DOUBLE LAMELLAR CATARACT (× 4)
Focal light pupil dilated fully

Causation. The crystalline lens is nourished by osmosis through its capsule. Its oxygen supply is derived through a complex internal autoxidative system Any interference with the nutrition of the lens will cause its transparency to become impaired with the production of cataract. The bulk of cataracts are found in elderly patients. These senile cataracts are more common in diabetics but there is a type of subcapsular cataract particularly associated with diabetes Cataract may be associated with tetany with rickets, mongolism dystrophia myotonica It may be secondary to iridocyclitis, glaucoma or old retinal detachment Trauma may cause cataract. If the lens capsule is split or incised the lens matter swells and becomes opaque If the aqueous has adequate access to such lens matter disintegrative enzyme action occurs and there is a tendency for natural absorption in the young. Cataract may also form under the influence of radiational energy such as heat, infra-red radium or X rays. It may follow the ingestion of poisons, such as naphthalene or dinitrophenol and possibly focal sepsis. A number of cases are congenital in origin.

Non-operative Treatment. There is no effective treatment of established lens opacities. The progression of cataract may sometimes be retarded by treatment of concurrent disease, such as diabetes.

Indications for Operation. The cataract may be extracted as soon as its presence seriously inconveniences vision. Technically the task is a little

the orbit at its upper and inner angle. Care must be taken not to inject the procaine intravenously A successful block of this nerve renders the cornea analgesic, and in conjunction with the blocking of the ciliary ganglion it gives adequate analgesia for removal of the eyeball if desired. The infratrochlear branch of the nerve supplies the lacrimal sac.

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FIG. 27 4 DOUBLE LAMELLAR CATARACT (× 4)
Focal light pupil dilated fully

Causation. The crystalline lens is nourished by osmosis through its capsule. Its oxygen supply is derived through a complex internal autoxidative system. Any interference with the nutrition of the lens will cause its transparency to become impaired with the production of cataract. The bulk of cataracts are found in elderly patients. These senile cataracts are more common in diabetics but there is a type of subcapsular cataract particularly associated with diabetes. Cataract may be associated with tetany with rickets mongolism, dystrophia myotonica. It may be secondary to iridocyclitis, glaucoma or old retinal detachment. Trauma may cause cataract. If the lens capsule is split or incised the lens matter swells and becomes opaque. If the aqueous has adequate access to such lens matter disintegrative enzyme action occurs, and there is a tendency for natural absorption in the young. Cataract may also form under the influence of radiational energy such as heat, infra-red radium or X-rays. It may follow the ingestion of poisons, such as naphthalene, or dinitrophenol and possibly focal sepsis. A number of cases are congenital in origin.

Non-operative Treatment. There is no effective treatment of established lens opacities. The progression of cataract may sometimes be retarded by treatment of concurrent disease, such as diabetes.

Indications for Operation. The cataract may be extracted as soon as its presence seriously inconveniences vision. Technically the task is a little

less difficult if there remains little or no soft lens cortex, such a cataract being traditionally known as "ripe" In such cases light thrown from one side of the pupil will cast no visible shadow on the lens, as the pupillary margin is in direct contact with the opaque lens on which its shadow is thrown With modern operative technique this test has largely outlived its value

The surgeon often has to consider the advisability of operation on a nilateral cataract, where the vision on the other eye is good This is because orrected vision in a lensless, or *aphakic* eye requires a lens of about +11·0 optres. Such a lens is difficult to use in conjunction with a normal eye ing to its prismatic effect, which causes diplopia if looking off the optical itre The image also is larger than that seen by the normal eye. These dvantages preclude the use of a corrected aphakic and a normal eye ether unless recourse is had to a contact lens, which presents many tical difficulties Used without correction an aphakic eye will only

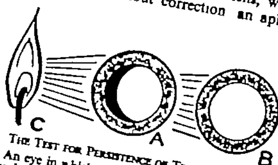


FIG 27 5 THE TEST FOR PERSISTENCE OF TRANSPARENT LENS CORTEX.
C, Light source A, An eye in which a nuclear lens opacity is separated from the iris by a layer of healthy lens fibres, so that a deep shadow is cast by the pupillary margin. B, The opacity is complete up to the capsule of the lens, so no shadow is cast. Such a cataract was formerly termed "mature."

note large objects and its chief advantage in conjunction with a normal eye is enlargement of the field of vision.

On the other hand cataract usually tends to be a bilateral condition. Extraction of a unilateral cataract gives the patient an eye in reserve which can be used if the second eye fails The prognosis of operation is not quite so good as age advances Secondary changes of "hypermaturity" in the cataract may make extraction more difficult. These arguments usually weight the scale in favour of operation on unilateral cataract, if the patient's health and expectation of life are good

Contra-indications to Operation. The chief contra-indication is a diseased retina with faulty projection, so that the patient is unable to point out the direction of a light. Operation in such a case might be surgically successful, but would not give the patient useful vision

No operation should be performed in the presence of iridocyclitis in the active stage, or of dacryocystitis or conjunctivitis

Pre-operative Examination of the Patient. Other relative contra indications are revealed by a systematic examination.

(1) A conjunctival smear should be taken to examine for organisms. Operation may be considered in the presence of *Corynebacterium xerosis* or *Staphylococcus albus* If there are such organisms as the pneumococcus, streptococcus, *Staphylococcus aureus* (coagulase positive), preliminary treatment of the conjunctival sac is required before risking a cataract extraction.

(2) Pus regurgitating on pressure from the lacrimal sac is a sign of *chronic dacryocystitis* In such cases the lacrimal sac should be excised before attempting operation

(3) There is considerable risk in operating in the presence of *dental sepsis* particularly apical root infection This is inclined to aggravate the complication of post-operative iridocyclitis If at all possible the patient should have dental treatment before an ophthalmic operation

(4) The chest should be carefully examined It may be necessary to operate in the presence of bronchitis of chronic type but coughing is liable to cause intra-ocular bleeding or prolapse of uveal tissue Any tendency to hyperpiesis should be known to the surgeon

(5) The urine should be tested for sugar and albumen

(6) Enquiry should be made as to any tendency to retention of urine In old men the prostate should always be examined Any herniæ should be noted A strangulated hernia shortly after a cataract extraction is usually an avoidable catastrophe

(7) Enquiry should be made into the state of the bowels Constipation should be avoided so should the opposite extreme of drastic purgation of elderly people

(8) Tactful enquiry should be made from a relative into the patient s consumption of alcohol In alcoholics judicious small doses should be given or delirium tremens may result.

(9) Care should be taken to encourage the patient. He should be given an optimistic nurse, and if a hospital patient given a cheerful companion. Panic on the part of the patient adds to the difficulty of the operation.

Technique of Cataract Removal. *Congenital Cataract* Under twenty five the most efficacious method of removal of the cataract is incision of the anterior lens capsule, when the lens matter will be gradually absorbed by the aqueous, leaving the eye aphakic. The operation may conveniently be performed under general anæsthesia with the pupil dilated with atropine An ophthalmic speculum is employed to separate the lids The eye is steadied by grasping with fixation forceps the adherent conjunctiva outside the limbus An ophthalmic *discission needle* is thrust through the corneoscleral junction and its tip made to incise the anterior lens capsule in the pupillary area During the absorption of lens matter the pupil is kept dilated with atropine.

Cataract in Adults There are two methods for removing a cataract in an adult In the first the lens capsule is grasped by special forceps, and gradual traction in different meridia ruptures the suspensory ligament of the lens after which the cataract can be gently withdrawn *intracapsularly* In the second method the anterior lens capsule is incised or torn away when the contained matter can be extruded *extracapsularly* by external pressure The following description refers to an intracapsular method which allows extracapsular removal of the lens if intracapsular extraction should fail because of tearing of the anterior lens capsule.

The patient is given bromides and a small dose of phenobarbitone as a pre operative sedative. The pupil is widely dilated by 1 per cent. atropine drops. The patient lies in the supine position. Several drops of 5 per cent. sterile cocaine solution are instilled for superficial anæsthesia. Deep anæsthesia is produced by retrobulbar injection of the ciliary ganglion, procaine is injected into the superior rectus and the facial nerve is blocked by the O Brien method The eye is irrigated by saline at body temperature, the

skin painted with surgical spirit and the head draped with sterile towels. An ophthalmic lid speculum is inserted and opened. A stay suture is passed through the superior rectus muscle, its free ends secured by an artery forcep. The surgeon stands at the head of the operating table working *from behind* the supine patient's head. Steadying the eye with a conjunctival fixation forceps, he takes a von Graefe cataract knife, employing his right hand for the right eye, and his left hand for operation on the left eye. The tip of the knife is made to enter the eye at the limbus, pass across the anterior chamber and emerge at the limbus on the opposite side. The knife then delicately cuts upwards, so as to form a transfixion flap upwards of cornea, and, if possible an additional conjunctival flap *Next, a small portion of* iris is picked up with straight iris forceps at the iris periphery and excised with de Wecker's iris scissors, leaving a small peripheral iridectomy Alternatively if the sphincter iridis seems atonic, a complete iridectomy is performed leaving a gap or *coloboma* from pupillary margin to iris periphery The corneoconjunctival flap is lifted by iris forceps. The surgeon now grasps hold of the anterior capsule of the lens with Duthie's extraction forceps. *Very slowly the lens is drawn laterally downwards and then slowly upwards* by the forceps, the movements in each direction being slow and delicate, continued until the suspensory ligament can be felt to part in each direction under the gentle and sustained traction. When the lens is felt to be free, it is gently drawn out of the eye by the forceps. Finally the corneoconjunctival flap is smoothed back into position by the iris repositor The flap may now be sutured into position with 6/0 plain catgut sutures 1 per cent. atropine *ointment is instilled and a petroleum jelly dressing, pad and bandage applied.*

Sometimes, in the course of breaking the fibres of the suspensory ligament, the anterior capsule of the lens is inadvertently torn by the Duthie's forceps This is an accident of little moment. The extraction can be completed by the extracapsular technique. Pressure with a lens spoon at or slightly below the lower corneoscleral margin will express the cataract from its capsule Any residual débris may be removed by irrigation with saline.

If the surgeon starts the operation with the intention of performing an extracapsular extraction, the only differences in technique will be that the iridectomy is usually performed after the expression of the cataract, while most surgeons use a cystitome or a pair of capsule forceps to open the anterior lens capsule. Many surgeons prefer to make the corneoscleral section with a peritome enlarging the opening by scissors and later sewing up with fine silk sutures. *Other surgeons inject a solution of* α-chymotrypsin into the anterior chamber This substance dissolves the suspensory ligament on which it has a selective action

Acrylic Implants Harold Ridley has introduced an operation in which an acrylic lenticulus is inserted inside the eye after performing an extracapsular cataract extraction The lenticulus lies behind the pupil and in front of the posterior lens capsule. Unfortunately the eye does not always *tolerate this artificial substitute for the crystalline lens, and post-operative* iridocyclitis is common Successful cases obtain dramatic improvement of vision. A variation in technique is to insert a lenticulus of appropriate power into the anterior chamber

Post-operative Treatment. Immediately after the operation, when the anterior chamber of the eye is empty of aqueous humour and the eye is

collapsed, movement by the patient does little harm some surgeons even allow their patients to walk back to bed from the operating theatre In a few hours aqueous humour refills the anterior chamber and there is some danger of bursting open the wound by sudden movements The patient must be kept quiet for forty-eight hours while the corneoscleral wound heals with some approach to firmness He should be hand-fed and the bed pan employed Pillows may be gradually allowed Octogenarian patients should be nursed sitting up from the start The patient should be kept strictly in bed no straining or rapid movement being allowed lest the wound burst open or hæmorrhage be set up The unoperated eye is covered by a flap which the patient can lift in emergency to look around while the operated eye is firmly bandaged The first dressing may be left for forty eight hours. It is a procedure of some delicacy owing to the fragile union of the wound edges An assistant should lift the patient's head from the pillow keeping the head steady by one hand below the patient's occiput, while the other lies beneath his chin The surgeon removes the bandages and dressings and the fixation lid stitch He then draws down the lower lid and observes the lower half of the pupil If this is well dilated and concentric with the corneal margin there is no need to raise the patient's upper lid for purposes of examination of the eye. A little sterile 1 per cent. atropine ointment is instilled inside the lower lid a fresh petroleum jelly dressing is applied and the eye is bandaged The same procedure is repeated on the subsequent days till the eye has healed

Temporary glasses are supplied at about the fourteenth day but owing to alteration in the post-operative corneal astigmatism final glasses are not prescribed for about six to eight weeks. Elderly patients are warned to be careful of steps, etc. as the increased clarity of images and their slightly enhanced size make the judging of distance a matter of some slight difficulty

After extracapsular extraction it sometimes happens that the retained epithelial cells of the anterior lens capsule may proliferate, causing an opaque diaphragm which interferes with clear vision, and calls for "capsulotomy" to leave a central aperture for vision.

Complications. At the operation there are a large number of minor complications which may occur from faults in technique. These are matters for a textbook of the specialty Loss of vitreous humour is always unwelcome, as such eyes are more liable to post-operative iridocyclitis and glaucoma whilst retinal detachment is a late complication

Among the other post-operative complications may be mentioned prolapse of iris following breaking open of an ineffectively healed wound. Such prolapsed iris tissue has to be abscised. Hæmorrhage into the anterior chamber may cause tiresome delay in recovery and sometimes the formation of fibrous tissue during the course of the absorption of the blood. Post operative iridocyclitis is a troublesome complication. It is likely to occur if there is much residual lens débris, or if there is present one of the ordinary causes of iridocyclitis, such as dental sepsis or diabetes. Secondary glaucoma may occur from adhesion of the pupil to lens capsule forming an impervious diaphragm preventing the circulation of aqueous, or from incarceration of uveal or capsular tissue in the wound. Rarely the eye may be lost from sepsis. Infection may spread from the wound into the eye, which is lost from *panophthalmitis* the eye having to be eviscerated. There are numerous other less common complications.

is instilled, also some penicillin ointment. A petroleum jelly dressing is applied and the eye is bandaged Any epithelial abrasion will be found to heal within twenty-four hours

Some surgeons prefer to employ a blunt tipped "spud" but most beginners contrive to remove large areas of epithelium with this implement without dislodging the foreign body

Perforating Injuries of the Eye

These are always serious in prognosis and demand skilled ophthalmic attention. The first duty of the surgeon is to decide whether any foreign body has been carried into the eye at the time of the perforation and, if so whether an operation should be attempted for its removal. This is done by careful general and ophthalmoscopic inspection and by X-ray examination.

Intra-ocular Foreign Bodies. Unless removed these may destroy the sight of the eye. Vital structures are often damaged during the entry of the foreign body Many eyes are lost by sepsis carried in by the foreign body others by *iridocyclitis and shrinking of the globe or by retinal detachment.* Iron and steel are dissolved chemically so that the resulting "siderosis" destroys vision. Aluminium alloys cause localized chemical necrosis. Copper and brass may cause suppuration or widespread toxic effects, such as "sun flower cataract." It is only occasionally that a foreign body is walled off by fibrous tissue and remains inert. All intra-ocular foreign bodies, involving, as they do a penetrating injury carry the danger of sympathetic ophthalmitis.

Magnetizable foreign bodies such as iron and steel should be removed by the giant electromagnet non magnetizable foreign bodies usually have to be left *in situ*, unless in the anterior part of the eye, where they may sometimes be removable by mechanical means. Every such operation has to be specially planned so as to avoid damage to the surrounding structures.

Foreign bodies in the orbit may usually be left alone if not readily removable through the site of entry Occasionally it proves necessary to explore the orbit through a lateral osteoplastic flap (Krönlein s operation).

If no foreign body is present the surgeon must next decide whether the eye is so severely damaged as to render it useless for visual purposes. In this case, excision of the eye is usually the wiser course, as a small proportion of *such eyes, if retained, give rise to sympathetic* ophthalmitis and loss of vision in the second eye. The danger does not usually arise before the second week after injury so that skilled opinion can usually be secured before excision.

In less severe cases the surgeon may attempt to conserve the injured eye.

Prolapsed Iris Uveal tissue protruding from the wound must be put on the stretch by iris forceps and cut away from its base by a quick snip of de Wecker s iris scissors. This procedure allows the elastic cut ends to retract inside the wound The temptation should be resisted to return protruding tags to the eye, as they are liable to introduce infection

Careful note should be made of any injury to the crystalline lens. An injured lens frequently swells up causing increased intra-ocular tension and "secondary glaucoma In such cases it may become necessary to make a *puncture through the cornea with a keratome,* insert a lens curette, and by gentle external pressure on the globe or by irrigation of the anterior chamber evacuate the lens débris After these procedures 1 per cent. atropine drops

are instilled and a petroleum jelly dressing pad and bandage are applied

Sympathetic Ophthalmitis. This most dreaded complication of perforation of the globe whether accidental or surgical is fortunately comparatively rare. The usual history is of a perforation of the globe in which iris or uveal tissue becomes implicated The wound does not heal readily and the eye remains irritable and injected from a slow iridocyclitis. Some time later usually not earlier than fourteen days after injury a similar iridocyclitis with exudation of cells and fibrin in the anterior chamber commences in the second eye The first eye is known as the "exciting eye" the second as the "sympathizing eye." Gradually vision is lost in both eyes from iridocyclitis and its complications of secondary glaucoma, cataract and phthisis bulbi The disease is particularly prone to occur in children Pathologically it is associated with a tremendous thickening of the choroid which is heavily infiltrated with large mononuclear leucocytes There is sometimes an inconstant increase in large mononuclear cells in the general blood-stream.

Once established treatment is ineffectual Removal of the exciting eye may lessen the intensity of the inflammation of the sympathizing eye, but some caution should be exercised as not infrequently the ultimate result visually is better in the eye originally wounded.

Sympathetic ophthalmitis is most unlikely if an injured eye is excised within fourteen days of the injury so that it is wiser to excise within this period any injured eye which does not retain useful vision. There is, however no need for precipitate enucleation immediately after an accident if a few days will allow expert ophthalmic treatment.

Chemical and Thermal Burns of the Eyes

The eyes are implicated in burns of the face less frequently than might be expected but careful examination should always be made to ensure the eyes remain uninjured. Singed lashes should be cut short irrigation with saline should be performed to wash out débris. The lid margins may be smeared with petroleum jelly If the cornea is damaged, atropine should be instilled The eyes should not be bandaged

Chemical burns of the eye require early and repeated irrigations. In the case of lime, great care must be taken to remove all particles from the conjunctival fornices. Bandages should be avoided, as the risk with chemical burns is of adhesion of the lids to the globe, or symblepharon.

In a severe case a piece of sterilized amniotic membrane may be stitched over a burned area of the eyeball. The interposition of this inert material will prevent the adhesion of the globe to the raw burned surface of the adjacent lid

Removal of an Eye

The removal of an eye is not a difficult procedure but careless work may readily cause a contracted socket in which the patient cannot wear an artificial eye. For this reason the simpler operation of evisceration is recommended to the inexperienced surgeon Immediate reaction is greater than with enucleation, but there is less liability to a contracted socket.

Evisceration. This is the best method where infection is present. The operation is preferably performed under general anæsthesia. The lids are separated by a speculum. The cornea is excised completely by scissors and forceps, leaving no residual corneal fragments. The contents of the

globe are scooped out with a sharp curette. Great care is taken to remove all the pigmented uveal tissue with the curette. A petroleum jelly dressing, pad and bandage are applied.

Enucleation. This may either be performed under general anæsthesia or where preferred under a combination of regional blocking with 5 per cent. procaine solution of the ciliary ganglion and nasociliary nerve, together with a few drops of 5 per cent cocaine solution in the conjunctival sac.

The lids are separated by speculum Any large perforation of the globe is temporarily closed by silk sutures The conjunctiva is incised with scissors all round the corneoscleral margin and carefully dissected back from the cornea so that it may be retracted to the equator of the globe The extrinsic muscles are raised on a bent probe or a strabismus hook and divided close to the globe, except for one muscle which is cut a few millimetres further back so as to leave a stump for traction purposes When all the recti have been divided and the eye has been pulled forward, a large curved pair of scissors is passed behind the globe and the optic nerve may be felt as a taut cord from globe to optic foramen. The optic nerve is then divided by scissors. When the globe is drawn forwards, the oblique muscles are exposed and may be divided close to the eyeball Bleeding from the socket is seldom severe and may be readily overcome by pressure from a swab held in artery forceps. The socket is ready for an artificial eye about six weeks after enucleation. A good artificial eye should be comfortable, should move slightly with the movements of the socket, and should match the remaining eye in the coloration of its iris and also the " white of the eye." Artificial eyes become roughened by the action of the secretions of the socket in course of time and usually require replacement after about eighteen months.

Differential Diagnosis of Red Eyes

Three main groups of vessels may be involved when an eye is inflamed

(1) The posterior conjunctival vessels, which spring from the tarsal arcades in the lids supply the conjunctival fornices, and pass forward a little way on to the globe

(2) The anterior conjunctival vessels or ciliary vessels which radiate from the limbus like a halo round the sun These vessels are mainly concerned with draining the iris and ciliary body



FIG. 27 7 CONJUNCTIVITIS.
Note injection of posterior conjunctival vessels and discharge clinging to lashes.

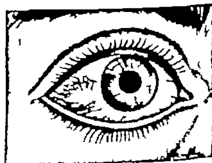


FIG. 27 8 SCLERITIS.
The lesion is bluish-red in colour and has deep radiating injected vessels.

(3) The scleral vessels which lie on a deeper plane than the conjunctiva and radiate in a meridional direction

When examining an inflamed eye the surgeon should first decide which of these groups of vessels are affected If the posterior conjunctival vessels

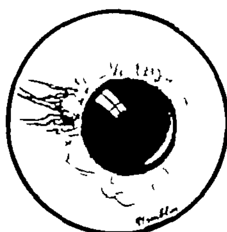


Fig. 27 9 Episcleritis.
Only the superficial scleral vessels are affected.

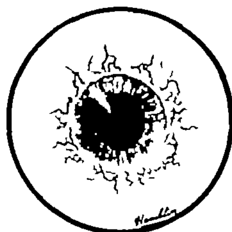


Fig. 27 10 Acute Congestive Glaucoma.
Cloudy Cornea, Semi-dilated Pupil, Shallow Anterior Chamber Ciliary Injection, Raised Tension.

are mainly affected the disease is probably a form of *conjunctivitis* In most cases there will be some conjunctival discharge and the surgeon should note if this is mucoid, mucopurulent or purulent. If the scleral vessels are affected in a *scleritis* (Fig. 27 8) there is usually an inflammatory patch

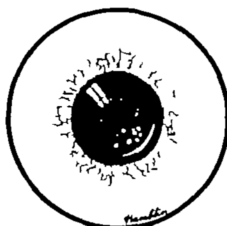


Fig 27 11 Iridocyclitis.
An attempt has been made to dilate the pupil but posterior synechiæ keep the pupil irregular Keratic precipitates from the ciliary body lie on the posterior corneal surface.

of a bluish-red colour extending sector wise from the cornea The vessels are deep to the conjunctiva, which can generally be moved superficially over the patch When pressure is made with the lid on the patch, the vessels are blanched with difficulty They run meridionally from the cornea and do not anastomose in the same fashion as the superficial conjunctival vessels.

If only the superficial scleral vessels are affected the condition is known as an *episcleritis*

Injection of the anterior conjunctival vessels around the cornea is known as "ciliary injection" If this is noted, the condition of the pupil should next

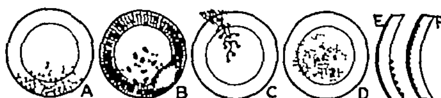


FIG 27 12. SPOTS ON, IN, OR BEHIND THE CORNEA.

A, Keratic precipitates ("K.P") of small size on the posterior corneal surface in iridocyclitis. B, Large "mutton fat" keratic precipitates on the back of the cornea in granulomatous tuberculous iridocyclitis. C, A dendritic ulcer involving the corneal epithelium. D, Spots of hyaline degeneration in Bowman's membrane "guttate keratitis." E, Section of cornea to show keratic *precipitates in iridocyclitis* (see A and B). F Section of cornea to show "guttate keratitis" (see D).

be examined. If this is semi-dilated and reacts sluggishly to light, the surgeon should suspect an *acute glaucoma* (Fig. 27 10) This tentative diagnosis may be confirmed by taking the tension of the eye and noting an increase above normal. The cornea will probably present œdema of the epithelium If the iris pattern is blurred or discoloured and the pupil reduced in size, the condition is probably an iritis or an *iridocyclitis* (Fig. 27 11) In this case the *tension is not likely to be raised on digital examination.* The instillation of

The Differential Diagnosis of Red Eyes

	Conjunctivitis	*Iridocyclitis*	*Scleritis*	*Congestive Glaucoma*
Type of Injection	Conjunctival	Ciliary	Radiating Bluish-Red	Ciliary
Corneal Condition	Normal	Keratic precipitates	Sometimes nodules	Cloudy *of* Haloes
Condition of Anterior Chamber	Normal	Normal. Aqueous may be turbid	Normal	Shallow
State of Pupils	Normal	Contracted or irregular	Normal	Semi-dilated. May be oval
Tension of Eye	Normal	Normal or raised	Normal	Much raised
Treatment	Penicillin. Sulphonamides. Antiseptics	Atropine. Cortisone (unless tuberculous). Heat. Treat cause	Treat cause	Diamox. Eserine Iridectomy
Special Notes	Contagion precautions	Inspect cornea for foreign body, ulcer keratitis		Use of atropine dangerous

homatropine will probably dilate the pupil irregularly as the iris is usually adherent by posterior synechiæ (adhesions) to the anterior lens capsule

Having examined the type of vessels injected and the pupil and tension the surgeon should now examine the cornea He may note a corneal foreign body A grey superficial patch is probably a *corneal ulcer* (Fig. 27 18) If there is a breach in epithelial continuity the area will stain green on instillation of a drop of 1 per cent fluorescein solution. The colour is enhanced by washing out surplus fluorescein with a drop of 2 per cent. cocaine solution. An inflammation of the corneal stroma is known as *keratitis* In keratitis the cornea does not easily stain with fluorescein According to the depth of the opacity in the stroma, the varieties of keratitis are designated as superficial, interstitial and deep Active inflammation of this sort must be discriminated from the sharply localized white corneal scars, known according to their degree of density as maculæ, nebulæ and leucomata In cases of iridocyclitis, small discrete masses of leucocytes are often noted on the posterior corneal surface. These patches are known as *keratic precipitates* or K.P A diffuse clouding of the epithelium is found in acute glaucoma.

Common Ocular Lesions

Conjunctivitis

Acute Conjunctivitis. Inflammation of the conjunctival mucous membrane may be due to a large variety of organisms The surgeon will often obtain guidance in treatment by the examination of the conjunctival discharges for organisms. Clinical examination is only a rough guide to the nature of the infection but it is possible to make some rough generaliza

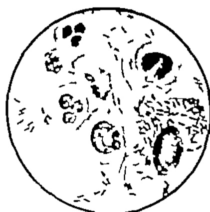


FIG. 27 13. THE KOCH-WEEKS BACILLUS IN A CASE OF MUCOPURULENT DISCHARGE.

tions Acutely red eyes with profuse mucopurulent discharge are usually due to infection with the pneumococcus. A rarer organism, the Koch-Weeks bacillus, sometimes causes epidemics of conjunctivitis of similar type. An irritation from inflammation of the corners of the eyes is usually labelled *angular conjunctivitis* This particular type is due to an organism, the Morax Axenfeld bacillus, which thrives on the transitional epithelium at the canthi. It produces proteolytic enzymes which cause the irritation. Zinc sulphate drops (¼ per cent.) have a specific action in rendering this enzyme impotent. The treatment has to be continued for a long time.

Occasionally in diphtheria and streptococcal infections, a *membranous conjunctivitis* may be seen.

Purulent conjunctivitis is not uncommonly gonococcal in origin. Gonorrhœal conjunctivitis is a condition of extreme severity whether found in infants or adults. In adults there is usually direct infection from a urethral discharge. The eye wells pus and the lids are greatly swollen. The conjunctiva is heaped up round the cornea (*chemosis*) Unless efficiently treated, the eye is lost by the formation and perforation of corneal ulcers.

Ophthalmia Neonatorum This is a name applied to conjunctivitis causing discharge in infants under twenty-one days old Such cases are notifiable to the Medical Officer of Health of the district, as they are frequently attended with serious results. The organisms found are staphylococci in 35 per cent., gonococci in 25 per cent. other coccal organisms 5 per cent., various bacilli 20 per cent. virus 10 per cent., undetermined 5 per cent.



Fig 27 14 The Morax Axenfeld Bacillus.

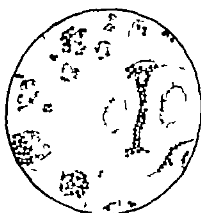


Fig. 27 15 Gonococci in a Case of Ophthalmia Neonatorum.

It will be seen that contrary to common opinion the gonococcal cases are in a minority The gonococcal cases are due to the infection of the eyes at birth by discharge from an infected mother The same method of infection is found in the cases of inclusion blenorrhœa from cervicitis of virus origin. After infection there is a latent period of a few days, after which a purulent discharge commences The appearances vary from a slightly sticky eye to a profuse outpouring of pus which distends the conjunctival sac. In the latter case the lids should be separated with care since it is not unknown for pus to spray into the face of the examiner on unwary inspection. In serious cases there is a danger of corneal ulceration with risk of corneal perforation and grave impairment or loss of vision.

Ophthalmia neonatorum is so readily cured by antibiotics that in this country routine local prophylactic treatment to the eyes of newly born infants is widely considered redundant Where antibiotics are unobtainable the Credé method of prophylaxis is valuable. This consists of wiping all discharge carefully away from the unopened eyes im [illegible] fter birth The lids are then carefully [illegible] and a single dro [illegible] nt silver nitrate solution is instille [illegible] ually enough to [illegible] causative organisms of ophthalmia

A unilateral purulent discharge from an infant's eye is usually secondary to a blocked nasolacrimal duct.

Chronic Conjunctivitis. There are two types of special significance

Phlyctenular Keratoconjunctivitis This is an allergic response shown by the conjunctiva commonly in tubercle-infected children A small white patch or phlyctenule forms usually at the corneoscleral junction Fine vessels may be seen running from the periphery to the patch. There is often severe photophobia, especially when the cornea becomes involved

Trachoma This is a serious conjunctival infection, due to a virus. Infection is transmitted directly by the discharge from an infected eye. The incubation period is from five to twelve days. In a typical case there is formation of follicles on the deep surfaces of the tarsal plates. The cornea is invaded in its upper part by a network of vessels (*Pannus*) (Fig. 27 17) Later scar tissue formation takes place round the follicles. Contraction of the scar tissue lessens the blood-supply of the follicles, which gradually decrease in number as the scarring increases. Unfortunately the contracting scar



FIG. 27 16 PHLYCTENULAR KERATO-CONJUNCTIVITIS.



FIG. 27 17 TRACHOMA SHOWING FOLLICLES AND PANNUS.

tissue often distorts the tarsal plates so that the lashes become inverted (*trichiasis*), causing corneal ulceration. Recurring attacks of corneal ulceration cause severe corneal scarring and may blind the patient.

Treatment of Conjunctivitis. In all types careful precautions should be taken to prevent the transmission of the disease In the epidemic types the patients should be isolated as far as possible Discharge should be wiped away with pledgets of cotton wool, which should be burned after use. The patient should frequently wash his hands and great care should be taken for the segregation of face flannels, towels, handkerchiefs, etc. Discharges should be washed away by frequent irrigations with lotions. Of these, normal saline at body temperature is as good as most. The action is mechanical by flushing away the infected secretions.

Mucoid and Mucopurulent Conjunctivitis These, the milder forms of infective conjunctivitis, generally respond readily to penicillin. Penicillin Ointment B.P., containing 1 000 units per g. instilled every two or three hours, or more frequently in severe cases, should prove adequate within a matter of hours. Treatment should be continued for two or three days after clinical cure to prevent relapse.

Angular Conjunctivitis This responds readily to the instillation of ½ per cent. zinc sulphate drops at four hourly intervals.

Purulent Conjunctivitis This is an acute emergency as the pus may erode the cornea producing an infected corneal ulcer with disastrous sequelæ Treatment must therefore be energetic. Oral administration of sulphadimidine in full doses (3 g. initially for an adult and 1 5 g. maintenance dose at six hourly intervals) should bring the condition under control within twenty-four hours. Treatment should be continued for two days after clinical cure Alternatively penicillin in a concentration of 10,000 units crystalline penicillin per ml. water should be instilled as drops at intervals of five minutes for half an hour By this time the condition should be under control, and the penicillin drops can be continued at less frequent intervals

Ophthalmia Neonatorum This should be treated as purulent conjunctivitis. The initial dose of sulphadimidine is one tablet (0 5 g.) with a maintenance dose of half a tablet (0 25 g.) six-hourly Sulphamerazine should never be used in infants as it has a tendency to crystallize out in the renal tubules and produce anuria. If penicillin is employed the procedure is as for adults.

Phlyctenular Keratoconjunctivitis This requires general rather than local treatment to the patient. Convalescence should be recommended in the country or at the seaside.

Trachoma In the early stages usually responds to painting the inside of the lids with 30 per cent. sodium sulphacetamide solution supplemented by 1 per cent chlortetracycline ointment Careful supervision for recurrences is necessary If inturned lashes from the scarred lids irritate the eye, relief may be obtained by such measures as the implantation of strips of buccal mucous membrane behind the lashes along the lid margin, or in extreme cases by excision of the tarsal plate Details of these procedures should be sought in special text-books. In localities where antibiotics are unobtainable it is customary to promote scarring of the lids by frequent paintings with silver nitrate solution (1 or 2 per cent) or by the application of a pencil of copper sulphate. If scar tissue is thus fostered, the disease will eventually attenuate. Corneal ulceration may be a serious complication of trachoma.

Corneal Lesions

Inflammation of the Cornea. Only the commoner forms will here be discussed Superficial inflammation involving the epithelium and subepithelial layers is often due to the virus of herpes febrilis by contamination from salivary sources. The corneal stroma is involved in the interstitial keratitis of syphilis, whilst the deeper layers may be affected in syphilis and tubercle. Treatment is that of the cause and of any secondary iritis which may be caused by the absorption of toxins from the lesions. The pupil should be kept dilated in all cases of active keratitis.

Corneal Ulceration. This may be diagnosed by the instillation of a drop of 1 per cent. fluorescein solution, which may then be washed out with a drop of 2 per cent. cocaine solution Areas denuded of epithelium stain green and are rendered obvious by this method.

Corneal ulcers may be secondary to conjunctivitis, or may be due to the infection of small abrasions, etc. Infection of such an abrasion by the pneumococcus is a serious mishap as a deep and sloughy ulcer is frequently formed, which has the additional disadvantage of being relatively painless,

so that the patient tends to postpone taking medical advic
pus forms in the anterior chamber where it tends to gravit
angle forming a *hypopyon* Subsequently the tension of th



FIG. 27 18 CORNEAL ULCER WITH HYPOPYON

weakened floor of the ulcer perforates and vision is seriously
even lost.

Scleritis. This is diagnosed by the violet-red colour of the
patch and by its localization to the scleral vessels. Treatment is
or hot bathing. The condition complicates spondylitis, syphilis
and tuberculosis so that it is primarily important as indicatin
for the cause.



FIG 27 19

a, b, c Pus in the substance of the cornea (onyx) *c* deep infiltratin
ulcer with undetermined edges *d*, pus in the anterior chambe
(hypopyon), a more common condition than onyx.

Treatment of Corneal Ulceration. In almost all cases there is al
of toxins from a corneal ulcer with resultant iridocyclitis The pup
therefore be kept dilated as a prophylactic measure with 1 per cent.
drops. If the lacrimal sac is infected it should be excised. Heat s
applied as for iridocyclitis. Resistant ulcers of—
chemical sterilization of the—

stained with fluorescein The ulcerated area is dried by a pointed strip of blotting paper The surface is then gently touched with pure phenol (carbolic acid) on a pointed wooden applicator care being taken not to allow the phenol to run over healthy corneal surface Hypopyon in itself requires no special treatment, as the pus is usually sterile

If the tension of the eye becomes raised and the perforation of the weakened floor of the ulcer appears inevitable it is wise to perform a paracentesis of the aqueous chamber A small puncture is made into the anterior chamber at the limbus, usually by a Graefe knife and the aqueous is allowed to escape This is better than allowing the spontaneous perforation through the floor of the ulcer since the outrush of aqueous frequently causes prolapse of iris tissue through the infected floor of the ulcer The eye may then be lost by infective panophthalmitis

Penicillin therapy has greatly improved the prognosis in hypopyon ulcer Penicillin is most effective when injected subconjunctivally A common initial dose is 200 000 u in 0 5 ml of 2 per cent procaine solution.

Corneal Grafting Dense opacities following corneal ulceration may be treated by corneal grafting. This may be either lamellar involving the superficial layers or full thickness. If the scar is vascularized prognosis is less favourable

Uveitis

Inflammation of the Uveal Tract The terminology is a little confusing to the beginner If the inflammation is confined to the iris, it is termed *iritis* If the ciliary body is implicated as shown by the presence of leucocytes on the posterior corneal surface, the condition is termed *cyclitis*. A combined inflammation of ciliary body and of iris is very common this being termed *iridocyclitis* Inflammation of the choroid is termed *choroiditis* or *choroido-retinitis, if the retina is also involved. If iris, ciliary body and choroid* are all inflamed the combined condition constitutes *uveitis*

All forms of inflammation of the uveal tract are of serious importance. There is usually a visible halo of " ciliary injection round the cornea in iritis and iridocyclitis the injected zone of anterior conjunctival vessels extending from the corneal margin for about 4 mm in serious cases. The iris pattern is blurred and in untreated cases the pupil is usually small.

When the pupil is dilated by atropine there are often adhesions of the pupillary margin to the anterior lens capsule, called " posterior synechiæ," so that the pupillary dilatation is limited by the adhesions and the pupil often assumes an irregular shape Under good illumination a deposit of leucocytes can be observed on the back of the cornea such deposits being known as keratic precipitates (abbreviated usually to K.P) Choroiditis (if present) requires ophthalmoscopic examination for its diagnosis.

Local Treatment This consists in the application of fomentations, hot bathing, steaming with a piece of lint tied round a wooden spoon and dipped frequently into hot lotion the electric eye heater or short-wave diathermy The pupil should be widely dilated by the instillation of 1 per cent. atropine or ½ per cent. hyoscine drops This puts the eye at rest and prevents iris adhesions in the pupillary area, with subsequent obstruction to vision. Careful watch should be made for the serious complications of rise of tension arising from obstruction to the normal drainage channels of the aqueous by inflammatory products.

Local cortisone is of great value in the treatment of iridocyclitis in the acute phase. It is contra indicated in tuberculosis, where it may remove barriers to the spread of the infection In iridocyclitis of other ætiology it may be used freely as local treatment The usual dose is 0 5 ml of the com mercial suspension (25 mg. cortisone acetate per ml of saline) This is given subconjunctivally Alternatively cortisone may be employed in drop or ointment form By the use of cortisone an acute attack can often be aborted In chronic iridocyclitis cortisone is usually ineffective.

The general condition causing the inflammation should be discovered if possible, and treated Common general causes include syphilis gonorrhœa tubercle gout diabetes, dysentery and the specific fevers. A certain number of cases are allergic in origin some are benefited by non-specific protein shock therapy as by the injection of T A B vaccine. Therapy by protein shock must be employed with caution as overdosage may cause aggravation of the condition.

Glaucoma

Acute Congestive Glaucoma. This is a serious surgical emergency caused by a sudden rise of intra-ocular pressure which destroys sight by retinal ischæmia and in prolonged cases by pressure atrophy of the fibres of the optic nerve. *The cause is not fully known, but it is thought that a histamine-*like substance is formed in the aqueous humour in these cases The choroid becomes turgescent and its rapid swelling forces forwards the lens and ciliary body so that drainage of aqueous humour is obstructed at the angle of the anterior chamber This causes rise in intra-ocular pressure, and the other symptoms are direct sequelæ of this sudden increase. The symptoms of the condition are somewhat variable, which often accounts for mistakes in diagnosis. *Sometimes the most prominent feature noticed by the patient* is pain, usually a dull ache in the region of the first division of the trigeminal nerve. Reflex vomiting may occur indeed, it is not unknown for cases of congestive glaucoma to receive prolonged treatment for digestive disturbance, to the exclusion of the ocular trouble. Loss of vision in the affected eye is often relatively unobserved by the patient.

On inspection the surgeon will note marked "ciliary injection" in most cases. The cornea is slightly cloudy from epithelial œdema. This cloudy epithelium may sometimes act as a diffraction grating, so that one of the classical signs of congestive glaucoma is the appearance of rainbow haloes round lights observed by the patients. Relatively soon this sign disappears owing to the general diminution of vision. The anterior chamber is shallow so that the iris is further *forward than usual. Owing to the* pressure on the nerve-supply of sphincter and dilator pupillæ, the pupil does not react readily and assumes the semi-dilated cadaveric position. The fundus cannot in most cases be seen through the ophthalmoscope owing to the cloudiness of the cornea and to vitreous haze. Digital estima tion shows a considerable rise in ocular tension.

Surgical Treatment A broad iridectomy should be performed through an incision just outside the corneoscleral junction, so that the iris may be excised at its extreme periphery This frees the canal of Schlemm, aqueous drainage is re-established and the intra-ocular pressure becomes reduced *Iridectomy in congestive glaucoma* is an operation demanding experience in ophthalmic operating and it should not be lightly undertaken by the

inexperienced surgeon A simpler operation than iridectomy is that of posterior sclerotomy in which a Graefe's cataract knife is used to puncture the globe behind the ciliary body and between the external and superior recti This operation will afford only temporary relief

Medical Treatment This should be instituted in the interval before treatment by an ophthalmologist but its effect is often unsuccessful. Reduction of tension may sometimes be obtained by the instillation of ½ per cent. eserine sulphate drops every half hour In favourable cases this will contract the pupil and pull the iris away from the occluded angle of the anterior chamber thus allowing the escape of aqueous humour and lessening the intra-ocular pressure.

The instillation of atropine drops in acute glaucoma is a tragic mistake which will aggravate the condition.

Acetazolamide (Diamox) may be given by mouth in an initial dose of 500 mg. followed by 250 mg. every six hours. This drug lessens the formation of aqueous humour and may thus lower the intraocular pressure

Chronic Glaucoma. This is a disease of different symptomatology from acute congestive glaucoma, the only common factor being an increased intra-ocular tension in both cases The cause of the condition is largely unknown there are probably several aetiologically different types. In some cases there may be overgrowth of the crystalline lens which presses forward the root of the iris so that a peripheral anterior synechia is formed and obstructs the aqueous drainage. In certain other cases flakes of anterior lens capsule become dislodged and float into the angle of the anterior chamber to block the outlet channels An epidemic form of the condition is sometimes found in association with the wet type of beri-beri.

All types have the common factor that the increase in tension is insidious. Under increased pressure the ocular coat yields at its weakest point, which is in the area of the optic disc. The disc becomes cupped or hollowed out by the pressure, so that an excavation rather like a jam jar in shape forms at the nerve-head. The axons of the retinal ganglion cells are stretched over the sharp edge of this excavation and tend to atrophy The capillary circulation in the bundles of nerve fibres at the disc is affected and disappears. Vision gradually diminishes typically by narrowing of the visual field rather than at first by loss of central vision. Glaucomatous optic atrophy gradually supervenes. Treatment is difficult and has passed through many fashions. On the whole the most satisfactory procedure is the Elliot trephine operation, by which a small safety valve is formed at the corneoscleral junction through a trephine hole by which the aqueous humour leaks away to be absorbed in the subconjunctival tissues Attempts are sometimes made to treat the condition by the regular instillation of pilocarpine or eserine drops, which act by constricting the pupil and freeing the angle of the anterior chamber Here again the instillation of atropine is a tragic mistake which may aggravate the condition. On the whole medical treatment is much less successful than the surgical relief of the increased tension.

Affections of the Lids

Stye. The hair follicles of the lashes may become infected. If there is an acute staphylococcal infection of a lash follicle a small abscess (*stye* or *hordeolum externum*) may be formed. This little abscess is remarkably painful owing to the extensive nervous supply of the area Eventually the

abscess bursts with rapid relief of pain Treatment consists of the application of heat and general measures to raise the resistance of the patient It is often possible to abort a stye by pulling out the affected lash Penicillin ointment is often helpful

Blepharitis. The lash-bearing margin is often the site of chronic inflammation of seborrhoeic or staphylococcal origin This is best treated by attention to the general health as the condition is almost always found in debilitated persons. If there is a refractive error glasses should be provided as they help to prevent the perpetual rubbing of the lids in which sufferers



FIG. 27 20. STYE OR HORDEOLUM EXTERNUM.



FIG. 27 21 MEIBOMIAN CYST OR CHALAZION.

from blepharitis are prone to indulge. Local measures include cleaning scabs from the lid margins with wetted pledgets of cotton wool and painting the lash-roots with a solution of brilliant green and crystal violet, or inserting Penicillin eye drops (500 units to 1 ml.).

Meibomian Cyst (*Chalazion*) This is a granuloma or sometimes an adenoma of one of the Meibomian glands of the tarsal plates of the lids. A rounded swelling like a pea forms in the substance of the tarsal plate. *The swelling may grow to considerable size. More often it perforates the* tarsal plate and extrudes its contents. If perforation occurs through the conjunctiva the swelling subsides Frequently the contents form a swelling superficially under the orbicularis oculi muscle, or they may pass down the duct of the gland to form a small granulation on the lid margin. Treatment consists of the evacuation of the granulation. The lid is best injected with 5 per cent. procaine solution. Two drops of 4 per cent. cocaine are instilled into the eye. The area of the lid affected by the chalazion is grasped by a fenestrated hæmostatic clamp forceps in such a way that the aperture of the forceps lies over the chalazion on the inner surface of the lid. The lid is then everted and the *chalazion is incised on the conjunctival aspect* A small disc of tarsal plate is cut out from the posterior surface of the chalazion, using scissors and fixation forceps. The contents of the chalazion are then carefully curetted out with a sharp spoon. A hæmostatic bandage should be worn for two hours after the operation to stop oozing of blood from the operation area.

Affections of the Lacrimal Apparatus

The tears normally drain down the lacrimal canaliculi into the lacrimal sac, and thence by means of the nasolacrimal duct into the inferior meatus of the nose *Obstruction of the flow most commonly takes place at the*

junction of the lacrimal sac and nasolacrimal duct, causing watering of the eye. Usually obstruction arises from inflammation which passes up the duct from its nasal end. In such cases the flow can usually be re-established by syringing saline through the passages. The inferior punctum lacrimale is dilated under cocaine anæsthesia by a cone pointed Nettleship's dilator. This allows the admission of the blunt tipped silver nozzle of a lacrimal syringe, by which a jet of saline is usually readily forced through the obstructed duct. In more difficult cases the duct may be cleared by the passage of a lacrimal probe through the canaliculus to touch the lacrimal bone, and then downwards along the nasal duct to the nose.

If obstruction to the duct is long-continued, the lacrimal sac often becomes infected. This may give rise to an *acute dacryocystitis* which is an acute cellulitis of the prelacrimal area at the inner canthus. Pus soon forms under tension, necessitating free incision. More frequently the sac forms a pocket of granulation tissue and pus, the condition being known as a *chronic dacryocystitis*. In the elderly the sac is usually best excised though in younger patients it is worth re-establishing the passage to the nose by performing the operation of dacryocystorhinostomy which constructs an artificial ostium from the inner wall of the sac to the nose through a hole in the bone of the lacrimal fossa.

The duct is sometimes obstructed by congenital septa, causing lacrimal suppuration in small infants. The passage of a lacrimal probe will usually cure this condition.

Lacrimal suppuration is sometimes simulated by subcutaneous extension of pus from an infected ethmoidal air sinus, so that an anterior rhinoscopy and intranasal examination should be performed on all cases before surgical measures.

Squint or Strabismus

This is occasionally paralytic and due to interference with the nerve-supply of one or more of the muscles. Most squints are convergent, and of the concomitant type in which the eyes move in unison, though not directed in the same direction. Convergent concomitant strabismus is a perversion of the normal synergic connection between convergence and accommodation. A child with hypermetropic eyes has to accommodate much more than normal in order to see distant objects clearly. Such increased accommodation would normally be associated with increased convergence which the hypermetropic child has to resist if single vision is to be maintained. An intercurrent illness such as measles or pertussis upsets the balance, so that the child squints usually in the eye of greater refractive error. Such a squint in an adult would be accompanied by diplopia but a young squinting child readily learns to inhibit or suppress the vision of the squinting eye. Such eyes gradually become "amblyopic" and lose the power of discriminative macular vision. After the age of eight years it is extremely difficult for such eyes to recover good vision.

The treatment of concomitant squint should be systematic. Since the primary cause was an error of refraction, this should first be corrected by appropriate glasses. This creates a state in which there is no active necessity for the child to squint and in many cases the squint promptly straightens up. If the squinting eye has become amblyopic, it should be practised in seeing by covering up the good eye by an occluding patch fixed to the glasses.

Care has to be taken that the child does not surreptitiously look round the edge of the occluder with the good eye Later it may be advisable to give a course of *orthoptic exercises* on various types of stereoscopes In resistant cases it may be necessary to straighten the squinting by operation The internal and external recti control the position of the eye in a similar way to the control of a horse s head by the reins. It will be seen that a convergent eye may have its direction corrected by increasing the traction of the external rectus or by setting back the insertion or otherwise weakening the action of the internal rectus. The numerous different operations for squint depend on the foregoing basic principles Operations for squint can be performed with success at any age when it is clear that the eye is not responding to non-operative measures there is no case for delay

Procrastination in the hope that the child may "grow out of the condition" is strongly to be condemned, as an untreated squinting eye will become amblyopic.

Ophthalmoscopic Appearances of Surgical Importance

Examination of the fundus oculi is of importance to the ophthalmic surgeon, to the physician and sometimes to the general surgeon, as the findings may have surgical value The following appearances are important

Papilledema. This is an important sign of raised intracranial pressure such as is caused by a cerebral tumour or cerebral abscess (see Plate 3) In such cases cerebrospinal fluid is forced from the cranial cavity into the subarachnoid space of the sheath of the optic nerve, which is, in fact, not a true nerve but part of the brain proper The arteria centralis retinæ has only a short course through this subarachnoid space in its way to enter the nerve. The vena centralis retinæ lies in the space for a considerably longer distance after leaving the optic nerve It follows that the thin walled vein is much more liable to compression from increased pressure in the subarachnoid space than the artery Such venous compression causes characteristic changes of appearance in the disc. The upper and lower margins of the disc become blurred in outline. Later this blurring extends to the nasal margin, and then to the temporal border of the disc. By this time the flat surface of the disc has been replaced by a flat topped mound of considerably larger diameter than a normal disc. It is possible to measure the degree of swelling of the disc with the ophthalmoscope by noting the difference in lenses required to focus the summit of the swelling and of the surrounding retina. A difference of 3 dioptres in the lenses is equivalent to 1 mm of swelling. Papillœdema does not in itself cause impairment of vision. There is, however associated venous congestion and in the later stages there may be hæmorrhages and white patches of coagulation necrosis in the vicinity of the disc Unrelieved papillœdema tends to terminate in blindness from post neuritic optic atrophy so that surgical measures may be required to prevent blindness. Indications for surgical interference are the presence of hæmorrhages and exudate on the disc, or prolonged swelling of over 4 dioptres. Obviously it is preferable to attempt surgical removal of the causative tumour rather than to adopt the method of lowering the intracranial pressure by palliative decompression only

Papillœdema in Malignant Hypertension This is found in advanced cases of malignant hypertension where the retina and disc become œdematous. Œdema of the optic disc gives the appearances of papillœdema. Œdema of

suturing the edges together Sclerectomy of this sort may be "lamellar" when confined to the superficial layers or "full thickness"

The third mechanism by which the retina may become detached is by being *lifted by propulsion from behind* This is sometimes caused by exudation as in eclampsia or renal disease The most common cause of a propulsion is a tumour such as for instance as a *malignant melanoma of the choroid* (Fig. 27 23) Retina detached by such a tumour tends to be in a much more regular curve than in the ordinary serous detachment. The area of the tumour does not transilluminate readily though there is often some concurrent formation of fluid beneath the retina which transilluminates except over the actual tumour No retinal hole is visible and the surface of the detached area of retina may show pigmentation. Malignant melanoma is a dangerous condition owing to the early formation of blood-borne metastases, which are found particularly in liver and lungs killing the patient by concurrent cachexia Local ocular changes may include hæmorrhage and increase of intra-ocular pressure

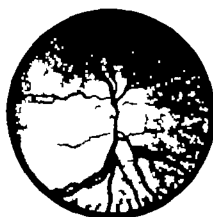
When the diagnosis is made the affected eye should be enucleated. This is advisable even where there are known to be metastases elsewhere in the body as otherwise the patient will suffer an unpleasant death with fungating masses of tumour in the orbit

Retinoblastoma. This malignant tumour of the retinal elements may arise in infants in the first two to three years of life. It presents itself as a white mass seen through the pupil Light directed on such an eye is widely dispersed forwards Hence an eye containing a retinoblastoma may be noticed by the parents to "shine in the dark" like an animal's eye. This accounts for the name "amaurotic cat's eye" formerly given to this tumour which is often also labelled "glioma retinæ" from a superseded view of the pathology

Retinoblastoma is extremely malignant killing its victims by extension to the brain along the optic nerve or by general dissemination. If the tumour is unilateral the affected eye should be enucleated Sometimes a primary tumour arises in the retina of each eye The choice then lies between bilateral enucleation and an attempt, rarely successful, to treat the tumours by irradiation.

Pseudo-glioma. This is an appearance simulating retinoblastoma but non neoplastic in origin It may be due to developmental abnormality to old uveitis, or to *retrolental fibroplasia.* This latter is an appearance sometimes found in premature infants of under 3 lb weight at birth The condition is usually bilateral and is thought to result from excessive oxygen administration Most eyes with pseudo-glioma are sightless and may become unsightly so that enucleation in these cases is often advisable

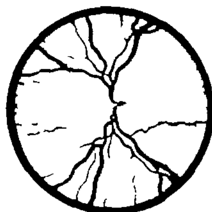
PLATE 3



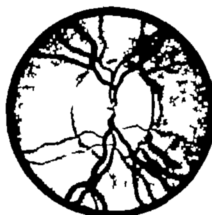
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OPHTHALMOSCOPIC APPEARANCES

1 The normal optic disc.
2. Papilloedema.
3 Post-neuritic or " consecutive " optic atrophy
4 Primary or simple optic atrophy
5 Glaucomatous cupping and atrophy of the optic disc.
6. Optic atrophy of retinal origin the waxy disc of pigmentary retinal degeneration.

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Chapter 28

THE EAR

Methods of Examination

The ear is examined by direct vision and by inspecting the external auditory meatus and membrana tympani through a speculum by testing the power of hearing and by ascertaining whether or not the Eustachian tube is patent with retesting of the hearing after inflation of the tube

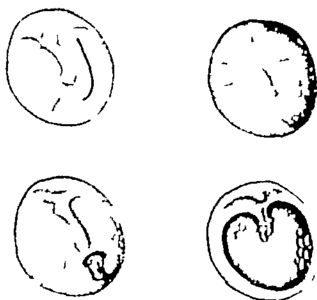


FIG 28 1 THE LEFT TYMPANIC MEMBRANE, AS SEEN THROUGH A SPECULUM.
Top left Normal tympanic membrane black line indicates the incision in myringotomy
Top right Acute inflammation of tympanic cavity with bulging of posterior segment of tympanic membrane and with dilatation of radiating vessels on anterior segment.
Bottom left Inferior perforation with discharge of pus.
Bottom right Destruction of most of tympanic membrane. Remains of malleus adherent to promontory Granulations are present posteriorly

Visual Inspection. The external ear is examined then the meatus by means of a speculum and mirror or by using an electric auriscope. In introducing the speculum the auricle is drawn backwards, upwards and outwards so as to straighten the cartilaginous portions of the meatus. The speculum held by the operator s thumb and first finger is then gently inserted and held in position. Reflected light illuminates the tympanic membrane, unless the

presence of wax, epithelial débris, or pus obstructs the view Such obstructions must be removed with a small hook, by cotton wool mops or by syringing the last only if it is known that no perforation is present. It may be impossible to insert the speculum because of dermatitis or furunculosis. The following points are to be noted in the normal membrana tympani (Fig. 28 1) The projection of the short process and handle of the malleus which runs from the centre or umbo upwards and forwards the cone of light extending forward from the umbo and at the upper border Shrapnell's membrane. The motility of the membrane should be determined by altering the air pressure by means of Seigel's pneumatic speculum its colour the presence of perforations, polypi, or adhesions, and also granulations or cholesteatomata, should be noted.

Investigation of the Hearing. This is carried out by testing the greatest distance at which the patient can hear the ordinary conversational voice, the whispered voice or the tick of a watch. Accurate measurements can be made with an audiometer

Discovery of the type of deafness is assisted by Rinne's tuning-fork test A tuning-fork of 512 double vibrations is placed in contact with the mastoid process and retained there until the patient can hear it no longer If now it is placed opposite the external auditory meatus, the sound should again be heard if the middle ear is normal It may be necessary to employ forks of lower vibration rate (256 or 128 double vibrations per second) for this test if the deafness is slight. Diminished perception by air conduction as compared with bone conduction is an indication of disease in the middle ear *Weber's test* consists in placing a vibrating tuning-fork in the middle line of the forehead When on one side there is middle ear disease or meatal obstruction, the sound will be heard more loudly in the affected ear

Perception of High Tones. This is tested with tuning forks, with a monochord, with Galton's whistle or with an audiometer Lack of appreciation of high pitches indicates involvement of the cochlea or auditory nerve.

A tuning-fork of 512 double vibrations is pressed against the mastoid process while the external meatus is closed by the surgeon's finger to determine absolute bone conduction. The patient is asked to state whether it is heard. The fork is repeatedly withdrawn and replaced until the patient no longer hears it. It is then pressed against the surgeon's mastoid process with the meatus closed. If he has normal hearing and still perceives the sound it is an indication of changes in the patient's inner ear due to senility or nerve deafness

Inflation of the Tympanic Cavity This is needed both as a test of the permeability of the Eustachian tube and also as a means of treatment in various conditions The methods of effecting it are as follows

Valsalva's Method. This consists in closing the lips, holding the nose, and expiring forcibly the air is thereby driven up the Eustachian tubes if they are patent movement of the tympanic membrane may be observed through a speculum.

Politzer's Method In this an indiarubber bag with a teat-like end is introduced into one nostril so as to occupy it completely The other nostril is closed by the surgeon's finger The patient is instructed to blow out the cheeks or to take a sip of water and to hold it in the mouth with closed lips until told to swallow As he blows or swallows, the bag is forcibly com-

pressed and air is thereby driven up the tubes An auscultation tube should pass from the patient s meatus to the surgeon s ear and various sounds—whistling bubbling, etc.—may be detected according to the character of the lesion

A *Eustachian catheter* can be passed into the Eustachian tube and the degree of inflation more accurately controlled The instrument, carefully sterilized, is passed with the beak downwards along the inferior meatus of the nose until the posterior pharyngeal wall is reached. As soon as its tip touches the posterior wall of the nasopharynx, the anterior end of the instrument is slightly raised and is withdrawn for about half to three-quarters of an inch until the beak is felt to be in contact with the posterior end of the hard palate The catheter is then rotated through a quarter of a circle until the beak points directly outwards. It is then pushed a little onwards and is usually felt to slip easily into the opening of the Eustachian tube.

The External Ear

Congenital Deformities. The pinna may be absent or rudimentary a defect usually associated with complete meatal atresia The external deformity is best rectified by the use of an artificial ear though in certain cases an operation may be performed to make a new passage A *pre-*



FIG. 28 2. ACCESSORY AURICLES IN A CHILD



FIG. 28 3. HÆMATOMA AURIS

auricular sinus or ear pit opening just in front of the helix is not uncommon and may be troublesome by virtue of recurrent infection. Cartilage is often found in association with it. Treatment should always be complete excision. *Accessory auricles* may be present consisting merely of fibrocartilage covered with fat and skin *Large and prominent ears* constitute a very unsightly deformity for which operative intervention is occasionally required.

Lop Ears or Bat Ears. The ears may stand out at an acute angle from the head and as well as appearing unsightly lead to mental distress in children. Operative treatment is employed after the age of 8 years an ellipse of skin and cartilage being excised posteriorly from the root of the pinna.

Injury *Hæmatoma auris* is commonly due to injuries sustained while boxing or playing rugby football. After a short period of time the auricle becomes swollen and enlarged, and of a bluish red colour unless the swelling is punctured and the blood let out, considerable deformity will result from its organization care must be taken to avoid infection which would lead to absorption of cartilage and contraction of the pinna

Infection. *Eczema and Diffuse Dermatitis* These are met with on the pinna and in the external meatus there may be obstruction from accumulation of epithelial scales and swelling of the skin lining the meatus. *Boils* or *furuncles* form in the follicles of the hairs guarding the external auditory meatus They cause great pain, and may produce deafness through obstruction If the local inflammation spreads, there is swelling behind the ear causing prominence of the auricle, making the diagnosis from mastoid abscess difficult. *If the auditory meatus be in the slightest degree patent,* or if a small speculum can be introduced hearing and tuning-fork tests will be found almost or quite normal in uncomplicated cases of furunculosis when acute otitis media, with or without mastoiditis, is present, there is marked deafness. It is unwise to incise boils in this region as cellulitis of the deeper tissues may be produced thereby

Neoplasms. *Exostoses* These occasionally form in the bony walls of the meatus they are seen particularly in those who swim a lot. They may cause deafness by obstruction. Almost always they should be left alone. It is only when they are responsible for serious loss of hearing, or when they interfere with the treatment of middle ear infections, that operation is indicated. The proximity of the facial nerve must be remembered and the operation should never be lightly undertaken.

Carcinoma. This may be basal-celled or squamous-celled and may attack the auricle or meatus. The former more common in men can be satisfactorily treated by excision or superficial irradiation though care must be taken to avoid perichondritis of the helix. Carcinoma of the meatus is a much more troublesome disease, affecting mainly women and tending to spread deeply and later to invade the middle ear producing much pain. Radical excision is difficult but radiotherapy does not give very satisfactory results.

Foreign Bodies. *Plugs of Cerumen* Wax, which becomes dark and very hard often blocks the meatus, leading to deafness this may come on through water getting behind the plug, as after bathing and causing rapid swelling of the plug. If they encroach on the membrana tympani, subjective symptoms of giddiness and rushing noises in the ear may also be caused. On examination with a speculum their presence is readily detected. *Treatment* consists in washing them away after previously softening with a solution of sodium bicarbonate or warm oil. A syringe with a tapered nozzle should be used, and a stream of warm normal saline solution projected along the floor or roof of the meatus as it returns, the softened masses of wax are washed away It is highly important, before syringing, to be assured that there is no perforation of a dry tympanic membrane *If one is present,* water should not be injected for fear of lighting up fresh infection the plug of cerumen should be removed by means of a small hook under direct vision. *Foreign bodies* in the meatus, such as *buttons* or *beads* are similarly removed, if possible, by syringing if this fails, a fine pair of forceps or a fine hook may be employed, but due care must be taken of the delicate structures behind

If difficulty is expected an anæsthetic is desirable Where other plans fail the auricle must be turned forwards and the meatus opened from behind

The Middle Ear

Traumatic Rupture of the Tympanic Membrane This is due to direct or indirect injury The former includes the introduction of foreign bodies or the ill advised efforts of friends or others to remove the same Indirect violence can cause rupture of the membrane by the sudden compression of the air in the external meatus *e g* by boxing the ear by the blast of explosions or big guns, or from diving Rupture of the membrane also occurs in some fractures of the middle fossa of the skull. The patient complains of immediate pain and subsequent deafness and in some cases blood escapes from the meatus, but not in any great amount. On involuntary inflation of the middle ear air can be heard to escape through the opening, perhaps with a whistling sound As a general rule these patients do well the tear healing, and the hearing being restored but the surgeon must at first give a guarded opinion as there may be some deeper lesion which does not immediately become apparent The greatest care must be taken to sterilize the pinna by mopping it with biniodide of mercury in alcohol The ear should be covered with a large sterile gauze dressing the army first field dressing is admirable for this purpose. No other steps should be taken. This precludes above all syringing, which is dangerous drops should not be instilled In some cases it is possible to close the perforation, if it persists, by means of an epidermal flap

Otitis Media

Inflammation of the middle ear is an exceedingly common affection and constitutes the great bulk of all ear diseases. It must be remembered that the tympanic cavity is lined by mucous membrane which is in direct communication through the Eustachian tube with that of the nasopharynx hence the cause is almost invariably an extension of inflammation along the Eustachian tube. The organisms usually present are the hæmolytic streptococcus and more rarely pneumococcus other pyogenic cocci may be found as secondary infections The inflammation may be catarrhal or suppurative, acute or chronic.

Acute Otitis Media. This is a very common disease in children, being secondary to lesions of the nasopharynx, such as an ordinary cold scarlet fever measles, etc., particularly if adenoids are present. It is ushered in by severe pain in the ear of a boring, persistent character together with deafness and some degree of fever The pain increases as the secretion accumulates, and particularly if the Eustachian tube become closed In consequence of the inflammatory hyperæmia of its lining wall, the tympanic membrane bulges outwards into the meatus Early treatment with penicillin will lead in a majority of cases to subsidence of inflammation otherwise local necrosis occurs in the membrane which finally ruptures, the pain being at once relieved. The discharge is serosanguineous if infection from the meatus is guarded against, and if penicillin or sulphonamides be given, inflammation may subside the perforation heal, and no ill result follow If the child is suffering from measles and if his powers of resistance are low the condition may progress to suppuration which may persist as a *chronic otorrhœa* for a lengthy period

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Treatment First, the possibility of secondary infection from the external meatus must be guarded against by thorough cleansing. A dressing is then placed over the ear Injections of penicillin should be given for five days, but the necessity for myringotomy must not be overlooked neglect of early drainage may be followed by deafness, after inflammation has subsided. Sulphonamides may be used they are however less effective than penicillin. *The child is kept in a warm room* *If the tympanic membrane is intact* glycerin instilled into the meatus helps to relieve pain In adults it may be possible with the help of steam inhalations and a spray of ephedrine (½ per cent. in normal saline) to reduce congestion at the orifice of the Eustachian tube in the nasopharynx, thereby relieving the hyperæmia and opening up the tube thus giving an exit to the retained discharge Pain is often relieved by fomenting the ear or by the application of heat

When the membrane is seen to be bulging, it is wise to incise it (*myringotomy*) as a clean cut heals better than a ragged perforation moreover *it is important to establish drainage early* The external ear and auditory meatus must be thoroughly purified with biniodide of mercury in spirit before operation General anæsthesia is required, and the incision is usually made just behind the handle of the malleus from below upwards. A dressing is kept over the meatus until healing has occurred.

Mastoiditis. This condition is caused by inflammation which extends into the mastoid cells. The complication makes itself evident in individuals with a cellular type of mastoid process they constitute 80 per cent. of the total, the remainder having a dense or diploetic type of bone

The mastoid process is a triangular mass of bone lying behind the auditory meatus it contains a greater or less number of cells lined with mucous membrane these cells communicate directly or indirectly with the antrum, while the latter itself communicates with the posterior part of the tympanic cavity (attic) by means of the aditus. At birth and in early years the antrum is solitary but later the mastoid process begins to develop and may be of two types (*a*) the *cellular* in which the whole bone becomes more or less hollowed out into a spongy mass of cells, which may extend upwards into the squamous temporal backwards over the lateral sinus, downwards to the tip of the mastoid process, forwards above the auditory meatus (zygomatic cells) inwards and forwards under cover of the facial nerve, or inwards towards the tip of the petrous bone (*b*) the *acellular* type, in which few cells appear the antrum remaining small, and the bone itself of ivory consistence As a rule, the cells lie below and superficial to the antrum which is more deeply placed in the adult than in the child the aditus is relatively larger in the child than in an adult The cellular mastoid is the type in which serious trouble develops in the course of exanthematous infections.

When purulent otitis media is associated with acute inflammatory changes in the mastoid air cells severe local and general *symptoms* may result, particularly if the aditus becomes blocked. The patient complains of pain in or behind the ear with tenderness on pressure, periosteal thickening and perhaps redness and œdema over the mastoid process. If there is a discharge from the ear it may cease for a time at the commencement of these symptoms, but reappears later As the case progresses, the febrile symptoms accompanying the initial attack of otitis media may persist or may reappear after a short intermission. An abscess may form under the periosteum covering the mastoid process, with or without caries or necrosis of the

outer table of the bone In children when this bony lamella is thin it may be absorbed and on incising the abscess granulations, springing from the interior of the bone may be seen When such an abscess has developed the auricle is characteristically displaced downwards and outwards Sometimes the suppuration extends through the bone cells and may encroach on the inner aspect rather than the outer and hence is likely to lay bare the dura mater and expose the lateral sinus in such circumstances intracranial complications are possible Occasionally a few thin walled cells occupy the tip of the mastoid and these may perforate downwards into the digastric fossa. Thus an abscess may form near the attachment of the sternomastoid and track into the muscle itself or into the neck this is known as *Bezold's abscess*

Rarely the trouble is of milder onset and may be tuberculous in nature, particularly in children under one year of age

Treatment In the early acute stage heat may be applied to the ear and the patient kept quietly in bed. Penicillin is given and alternatively or

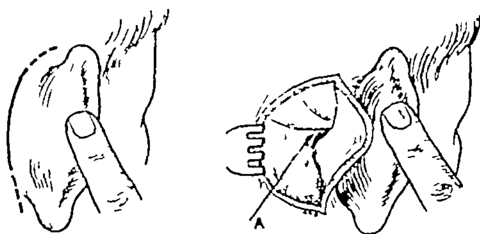


FIG. 28.4 SCHWARTZE'S MASTOID OPERATION.

Left Incision for mastoid operation, showing extensions upward and downward to suit circumstances. *Right* Position of the antrum (A) deep to the depressed area constituting MacEwen's triangle.

in addition sulphonamides, for about five days. They should not be continued longer unless some complication arises. In the majority of cases the inflammatory process will subside without perforation of the tympanic membrane and without the necessity for an operation

Cultures are required to determine the type of organism after spontaneous or surgical perforation of the tympanic membrane. It is important not to be precipitate with surgical intervention, unless some complicating factors arise An operation is seldom necessary under present conditions even if required eventually The best results are obtained if it is postponed until the end of the second week from the commencement of the attack of acute otitis. If, at the end of this time, discharge persists and there is still pyrexia, with tenderness over the tip of the mastoid, it is advisable to open the mastoid antrum and air cells through skin and periosteum, without interfering with the tympanic structures, which in acute cases are capable of effective repair (*Schwartze's operation*) A curved incision is made immediately behind the ear which is drawn well forwards, and after separating the peri-

osteum from the bone a gouge is applied on a level with the roof of the external auditory meatus, and about 1 cm behind its centre. A small dimple in the bone can often be felt at the required spot, which can also be found by taking the point of junction of two lines drawn as tangents to the roof

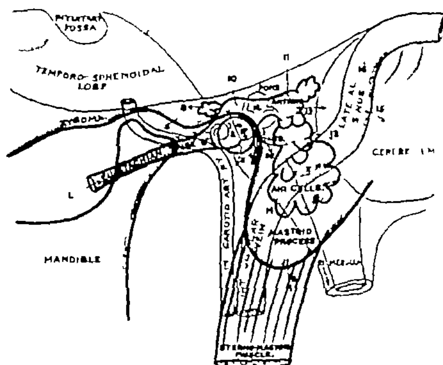


FIG. 28 5. COMPLICATIONS OF OTITIS MEDIA.

1 Infection of middle-ear tract from nasopharynx *via* Eustachian tube. 2. Escape of infective material through a perforation into external auditory meatus. 3 Caries of malleus or other ossicles. 4 Involvement of facial nerve. 5 Spread to temporo-mandibular joint. 6. Erosion of internal carotid artery by spread from Eustachian tube. 7 Destruction of cortex of mastoid air cells with periostitis and mastoid abscess. 8 Zygomatic abscess due to forward spread of infection. 9 Extension through tip of mastoid process into sheath of sternomastoid muscle, causing Bezold's abscess. 10. Caries of tegmen tympani leading to extradural and temporosphenoidal lobe abscess. 11 Caries of roof of antrum causing involvement of meninges or cerebral abscess. 12. Spread from antrum or air cells to cerebellum. 13. Infection from mastoid air cells causing perisinus abscess and lateral sinus thrombosis. 14. Septic thrombus spreading down internal jugular vein. 15. Infection of cerebellum from septic focus in lateral sinus. 16. Septic thrombus extending towards torcula Herophyli. 17 Destruction of promontory wall, causing labyrinthitis. 18. Caries of wall of external horizontal canal with fistula formation and labyrinthitis. 19 Infection from labyrinth travelling to cisterna pontis *via* internal auditory meatus. 20. Infection travelling by internal auditory meatus to cisterna basalis. 21 Meningitis spreading down spinal cord.

and posterior wall of the bony meatus respectively The direction taken by the gouge should be slightly downwards, forwards, and inwards. In an adult the mastoid antrum is reached about three-fifths of an inch from the surface of the bone. The surgeon recognizes that he has opened the cavity by the probe, or by the loss of resistance and escape of pus The opening is

enlarged by the use of the gouge and spoons, so as to remove all diseased bone and all the air cells and the cavity is then syringed out. Every cell must be freely laid open into the wound as otherwise the infection will continue to spread through the bone and cause further trouble all edges must be left sloping with no overhanging lips It may be necessary to remove the tip of the mastoid process, if cells extend into it and always when Bezold s abscess is present The wound is filled with penicillin and sulphathiazole powder and closed with a small drain at the lower end the drain can be removed after twenty four hours Many surgeons dispense with drainage altogether

The factors that may persuade the surgeon to operate earlier than after a lapse of fourteen days are (*a*) the presence of a subperiosteal or subcutaneous abscess in the neighbourhood of the mastoid antrum or air cells, (*b*) thrombosis of the lateral sinus, (*c*) paresis or paralysis of the facial nerve or (*d*) brain abscess, complications which are described elsewhere.

Chronic Otorrhœa. This follows an unarrested acute attack The membrane is perforated while discharge varies in amount and character In uncomplicated cases treatment consists of (*a*) Improvement of the general health, especially residence in a bracing climate, preferably by the sea (*b*) Attention to the nasopharyngeal condition so as to ensure a healthy condition of the Eustachian tube. Steam inhalations or decongestive nasal sprays may be ordered while adenoids and enlarged tonsils may require removal. Any sinus infection must be treated (*c*) The middle ear must be kept free by mopping out any accumulation of discharge which might undergo decomposition When the purulent secretion is abundant the meatus should preferably be mopped out or alternatively be syringed with sterile saline or weak boric acid solution If the discharge is offensive or difficult to dislodge the occasional use of drops of peroxide of hydrogen (10-volume strength) will be found useful before syringing. If the discharge is slight, the meatus may be insufflated with boric acid powder containing 0 75 per cent. of iodine and syringing avoided. Drops of alcohol (S V R.) are of use if instilled twice daily Drops of chloramphenicol 10 per cent. in propylene glycol are of value in treating mixed infections Not infrequently however a persistent discharge from the ear is due to some of the complications mentioned below and operative treatment may be required.

Surgical Complications of Otitis Media

These are often serious, and call for prompt treatment they may be classified under four headings—those affecting the external middle and internal ear and those involving the intracranial contents.

Complications Affecting the External Ear These may be very disturbing.

Dermatitis This is frequently seen the meatus must be kept as dry and clean as possible and drops of weak mercury in almond oil should be instilled (dilute Mercuric Nitrate Ointment, B P., ½ fl. dr (2 ml.), Almond Oil, B P., 1 fl oz. (30 ml)) Dermatitis usually disappears when the discharge ceases, but is not infrequently associated with enlargement and suppuration of the cervical nodes. Chloramphenicol drops are useful.

Boils These arise from pyococcal infection of the hair follicles in the meatus, and are exceedingly painful, owing to the denseness of the tissues involved. A pledget of wool soaked in 5 per cent chinosol in glycerin may be inserted and left from fifteen to twenty minutes, followed by drops

of mercury ointment in almond oil Ichthyol (10 per cent.) in glycerin is an alternative Incision should be avoided because of the danger of causing diffuse cellulitis. Penicillin is of value with a change to some other antibiotic if the organism is insensitive

Complications in the Middle Ear These are often of a grave nature, and may endanger life.

The Ossicles These may become carious, the hearing being impaired.

Inflammation This may extend to the bony walls of the tympanic cavity giving rise to necrosis of the temporal bone This may be associated with suppuration within the skull, and any of the intracranial complications mentioned below The roof of the tympanic cavity (tegmen tympani), which is very thin, is especially liable to be affected in this way

Polypi These may develop in chronic cases they consist essentially of granulation tissue protruding through the opening in the membrane, thereby hindering the escape of discharge If it seems reasonably certain that there

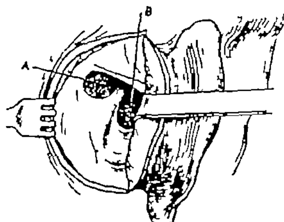


FIG. 28 6. RADICAL MASTOID OPERATION.

The antrum (A) has been thoroughly opened up, and the bridge of bone covering the aditus removed, thus bringing the antrum into free communication with the tympanic cavity (B), which is curetted and the ossicles removed, if disorganized. In some cases part of the tympanic membrane with the attached handle of the malleus may be left *in situ*.

is no underlying caries of the walls of the inner ear or of the canal containing the facial nerve they may be removed by the snare or curette and the base touched with a bead of fused chromic acid.

Cholesteatoma This condition may result from ingrowth of epidermal cells into the tympanic cavity through a perforation in cases of chronic otitis media of some years duration. Squamous cells are cast off and mix with bacteria and secretions to form a mass which by swelling and expansion due to gradual absorption of moisture, may destroy parts of the bony walls, sometimes causing intracranial complications

Facial Paralysis This may arise in chronic cases from caries of the bony walls surrounding the aqueductus Fallopii causing inflammatory changes around the facial nerve in the canal Inflammatory spread into the sheath of the nerve may also occur in acute cases, with paresis or paralysis of the facial muscles. It must be remembered that the bony canal lies immediately behind the tympanic cavity and in some cases in close relation to certain mastoid air cells. More especially in cases of tuberculous nature the nerve

may be actually exposed as a result of necrosis or absorption of the bony wall of the aqueduct and this may lead to direct infection or even destruction of the nerve itself

In some chronic cases, where discharge is kept up by infection of the mastoid antrum or where cholesteatoma or caries of ossicles are present an extensive proceeding known as the *radical mastoid operation* is required The cartilaginous meatus is detached posteriorly from the bony margins and the antrum is opened and the whole of the osseous tissue intervening between it and the meatus and tympanic cavity in front is gouged away In the region of the ridge of bone over the facial nerve particular care is required to avoid damage The remains of the membrane together with the remains of the malleus and incus are removed if grossly diseased and the cavity curetted the stapes must on no account be disturbed (Fig. 28 6) The deep portion of the posterior wall of the cartilaginous meatus is incised above and below and the flap so formed is stitched to the posterior edge of the wound the meatus thus leading to the cavity in the bone which can in this way be cleansed more efficiently Thiersch-grafting is sometimes employed to secure more rapid epithelialization of the wound in the bone. Alternatively the endaural approach may be employed it is preferred by some surgeons. In this operation incisions are made in the skin lining the external meatus to form a flap and thus to expose the postero-superior bony wall the antrum is then reached by removal of relatively little bone.

Involvement of the Internal Ear (*Labyrinthitis*). This may be localized or diffuse and results from the spread of infection inwards, either through the wall of the external semicircular canal or through the fenestra rotundum or ovale in the former case the posterior or vestibular portion is involved, in the latter the cochlea The endosteum remains intact in circumscribed cases, symptoms being due to irritative inflammation, with a rise in fluid pressure in the labyrinth In such cases compression of air in the auditory meatus by means of a rubber bag causes the fistula sign of vertigo and nystagmus. If the endosteum is perforated, with diffuse labyrinthine infection, all function is lost in the internal ear both for equilibration and hearing. The condition may arise in both acute and chronic cases. Invasion of the semicircular canals is evidenced by vertigo a tendency to fall, nystagmus and vomiting pain and fever are present in the more acute forms Involvement of the cochlea results in tinnitus and deafness. The hearing varies according to the degree of involvement it is reduced in circumscribed labyrinthitis and completely lost in diffuse, suppurative cases. As the perilymph and endolymph systems of the semicircular canals, utricle, saccule and cochlea are in direct communication, inflammation in one region rapidly involves the other subdivisions. Infection of the meninges often arises by spread of inflammation along the internal auditory meatus.

Intracranial Complications. These are relatively more common in the acellular type of mastoid, inasmuch as it is almost impossible for the inflammation to extend towards the surface and is liable therefore to progress deeply Thus these complications occur more often in cases of chronic suppurative otitis media

Extradural Abscess This condition is described in greater detail in Chapter 23 Accumulations of pus occur most commonly along the upper surface of the petrous portion of the temporal bone, more commonly in subacute cases. The patient complains of pain and headache extending

over the affected side of the head, which gradually increase and are followed by drowsiness The complication may arise after years of chronic otorrhœa, and is sometimes associated with sudden cessation of discharge The temperature is raised but true rigors are very rare The pulse is of the usual febrile type, viz quick full and bounding. *There is no pain in the neck along the course of the jugular vein but retraction of the head occurs if basal meningitis appears vomiting may occur* Papillœdema may be observed, but more commonly is absent. There may be *some tenderness on pressure over the temporal region and possibly œdema*

The treatment consists in enlarging the opening made in the bone for treatment of the mastoid trouble, so as to ensure efficient drainage. As much bone is removed as will ensure thorough exposure of all affected dura the latter is usually covered with granulations in the exposed area.

Meningitis Sometimes this is an early complication of acute otitis media. It is due *to extension of infection from the middle ear-tract, generally* through caries of the tegmen tympani or antri the meninges may adhere together wide spread of infection being prevented thereby *Rapid spread* occurs, however in cases where the meninges have not been sealed together by a gradual adhesive process. The route of entry is sometimes through small veins *spread from the infected internal ear may travel through the* internal auditory meatus to the cisterna pontis or basalis.

Treatment is by sulphonamide therapy together with penicillin and not by operation in the early stages Penicillin, to be effective, must be injected intrathecally *An operation on the mastoid is desirable later to remove the source of infection but is not performed until the patient has been* made sufficiently fit by the above treatment

Thrombosis of the Lateral Sinus This arises from extension of the inflammatory process from the middle ear through the mastoid bone. *It may occur in the course of an acute attack, or may be a complication of long*-standing cases, particularly when there is an acute exacerbation. A clot forms within the sinus, possibly at first on one wall, without completely stopping the blood-stream (mural thrombus) *thus, gradually increasing* in size, leads finally to occlusion of its lumen Infection with pyogenic organisms determines disintegration of the clot infected emboli are detached, and thus pyæmic symptoms originate. *In well-marked cases the thrombus extends back as far as the torcular Herophili, and downwards along the* jugular vein

The most marked symptom of the case is a sudden rise of temperature, which is usually hectic associated with *rigors vomiting, and localized* pain in the head perhaps most marked over the point of emergence of the emissary vein at the posterior border of the mastoid process The pulse is rapid, feeble and easily compressible and in the later stages the patient is *drowsy and dull probably from serous exudation within the meninges. Optic neuritis may or may not exist, being often preceded by photophobia* If the thrombus extends into the neck, a firm tender elongated swelling is felt in the region of the jugular vein. The cervical *lymph nodes become* enlarged *stiffness of the muscles at the back of the neck is an evidence of associated* basal meningitis, as also is papillœdema. *Suppuration may occur* outside the sinus or around the vein in the neck.

In well-marked cases the diagnosis is easily made, but in the early stages, *and especially in children it is often a matter of some difficulty The abrupt*

onset the swinging temperature the recurrent rigors the pain in the neck and the deep tenderness on pressure over the course of the lateral sinus or jugular vein are the most trustworthy signs of this affection Lumbar puncture reveals normal cerebrospinal fluid but Queckenstedt s test is positive, that is to say there is no rise in pressure when the jugular vein is compressed

The treatment must depend upon the control of infection by sulphonamides and antibiotics together with an operation to expose the lateral sinus In acute cases the cortical operation is carried out but chronic cases require the radical procedure If after exposure there is doubt about thrombosis the sinus should be opened and any small clot removed with a catheter attached to a suction pump Both unaffected ends of the sinus beyond the area of clotting, are then packed off by insertion of ribbon gauze between the sinus wall and the bone If on the other hand obvious thrombosis is found at operation it is wise first to tie the internal jugular vein and then to return to open and pack off the lateral sinus As backward spread may occur it is necessary to obliterate the venous canal behind the area where clotting has occurred

Cerebral and Cerebellar Abscess A description of these complications which rarely follow otitis media will be found in Chapter 23

Carcinoma of the Middle Ear This differs markedly from cancer of the external meatus. The latter should be diagnosed only when healthy meatal wall can be seen all the way round beyond the lesion. If this is not so then it is probable that the visible growth is extending outwards from the middle ear The condition is sometimes found associated with chronic suppurative otitis media or with cholesteatoma Treatment is difficult because of spread into the petrous bone Excision is desirable and involves removal of the whole auricle plus the radical mastoid operation Radiotherapy as a post-operative or primary radical measure is also given

The Inner Ear

Diseases of the inner ear do not concern the surgeon very greatly Two exceptions which are to some extent amenable to operative treatment may be mentioned.

Otosclerosis. This is a disease of unknown origin causing deafness in young adults. It is usually progressive and the deafness is caused by the fixation of the stapes in the fenestra ovalis If tests show that the cochlea is functioning normally operative treatment is sometimes justified. A new window or fenestra is created by drilling through the external horizontal canal as far forward as possible, but with care to avoid injuring the facial nerve The endaural approach is commonly employed and a flap fashioned from the skin of the meatus with the upper part of the tympanic membrane, is placed over the newly made window About 80 per cent. of immediate good results are obtained and some 50 per cent. of permanent successes. An alternative is mobilization of the stapes, after exposure of the middle ear and its ossicles by detaching and turning down the upper segment of the tympanic membrane. In many cases it is possible to lever the stapes free but there is a possibility that it may break In unsuccessful cases fenestration may be required

Ménière s Disease. This disease or symptom-complex is characterized

by attacks of nausea, vomiting or even collapse in addition to vertigo tinnitus and deafness It is attributed to hydrops in the cochlea, due to interference with the production and absorption of endolymph. Allergy may play some part. If medical and dietetic measures fail to relieve symptoms it may be decided in carefully selected patients to destroy the labyrinth on the affected side This is accomplished by exposing and opening the horizontal canal, with injection of alcohol or removal of the membranous duct.

In severe cases the hearing on the affected side is already very much reduced and distorted so that the total deafness resulting from the operation is not disastrous Certain methods of operation enable hearing to be retained.

Preganglionic section of the sympathetic nerves from the first and second thoracic segments has also been recommended and is, in some cases, of benefit.

Chapter 29

THE LIPS AND JAWS

THE LIPS

Cleft Lip and Cleft Palate. Cleft lip or as it used to be called hare-lip is developmentally associated with cleft palate and indeed the two conditions often co-exist. It is therefore logical to consider these together Since the operative treatment has passed largely to the plastic surgeon reference should be made to Chapter 40 for an account of these conditions.

Oblique Facial Cleft This is a very rare deformity characterized by a cleft or sulcus in the face, starting from the usual situation of a hare lip below but running up outside the nostril to the inner side of the lower lid



Fig 2 91 Oblique Facial Cleft with Cicatricial Deformity along the Line Traversed by the Cleft



Fig. 29 2. Macrostoma with Auricular Appendages.

Coloboma of the iris or choroid is sometimes associated with this rare defect. The deformity is due to non-closure of the naso-orbital fissure, and runs along the line of the nasal duct. It may be limited to the soft parts, or may involve the bones, even laying open the antrum.

Macrostoma. This is characterized by an abnormal width of the mouth, and is due to non-union of the maxillary and mandibular processes. It may be uni or bi-lateral, and is usually associated with anomalies of development of the ear accessory auricles being often present. As a rule a small papilla on the upper and lower margins will indicate the true limits of the mouth, being constituted by the points of attachment of the orbicularis. The existence of these is of great importance as indicating the extent to which the cleft must be pared in order to restore the mouth to its normal size.

Mandibular Clefts. These are exceedingly rare. They are due to non-union of the mandibular processes in the middle line, and involve either the soft tissues of the lower lip alone or may extend to the bone, and even the tongue.

Microstoma. This term is applied to a condition in which the fusion of the parts entering into the formation of the lips progresses to a greater extent than usual, so that the oral orifice is contracted It may be associated with defective development of the lower jaw In the more severe cases, where the mouth is extremely narrowed, a transverse cut should be made outwards on each side, and the mucous membrane stitched to the skin.

Macrocheilia. Hypertrophy of the lip occurs in three forms (*a*) The congenital variety a condition analogous to macroglossia, and due to a congenital distension of the lymphatic spaces, or chronic lymphangiectasis accompanied by overgrowth of the connective tissue. The lower lip is most often involved and is firm, thickened, and everted causing considerable



FIG. 29 3 CHANCRE OF THE LOWER LIP
The submandibular lymph nodes are enlarged.



FIG. 29 4 PAPILLOMA OF THE UPPER LIP

deformity The treatment consists in the removal of a V-shaped portion from the centre (*b*) An acquired form occurs in children and young people constituting the so-called "strumous lip The thickening is due to a chronic lymphangitis, resulting from the absorption of toxic material from *persistent cracks and fissures. If these can be healed* diminution in the size of the lip soon follows (*c*) In adults, macrocheilia is in almost all cases due to tertiary syphilis The lower lip is most often enlarged, and becomes thick and hard It is due to the diffuse sclerosis characteristic of tertiary disease. General treatment, and not local, is needed

Syphilitic Affections. These are becoming quite rare. A *primary* chancre may be caused by kissing, or by smoking an infected pipe or drinking from a glass with an infected rim It usually presents a *smooth ulcerated* surface, discharging a small amount of seropus, resting on a mass of infiltrated tissue which may extend over the whole lip (Fig. 29 3) The induration *is not so great as in chancres upon the genital organs*, but the infiltration is much more extensive. Enlargement of the submandibular lymph nodes occurs very early and the disease usually runs an active course. A labial chancre may closely resemble carcinoma, but is distinguished from it by its rapid development up to a certain point, by the early implication of the nodes,

which soon become very large, by the positive Wassermann reaction by the age of the patient, and the course taken by the case as well as by the local appearances. The surface is usually flattened and less warty and irregular than in carcinoma while the skin is more involved than the mucous membrane Moreover it is more common on the upper lip while carcinoma is usually seen on the lower In the *secondary* stage mucous tubercles are frequently met with involving the inner side of the lip and the angle of the mouth In the *tertiary* period serpiginous ulceration and gummata may occur or the diffuse induration described above. In *inherited* syphilis, cracks and mucous tubercles are constantly present, and may be so extensive as to leave cicatrices radiating from the mouth which are very characteristic.

Cracked Lips. Chapped lips are usually the result of cold weather a central crack or fissure forming which is extremely painful and liable to bleed very readily on everting or stretching the part. The lower lip is that generally affected *All that is needed in the shape of treatment is the application* of a little lanolin or cold cream but if they persist, it may be advisable to touch them with nitrate of silver

Herpes Labialis. This is a condition usually associated with catarrh, and quite often with pneumonia or other fevers. Either lip may be affected and the herpetic eruption is quite limited in extent. It consists of a number of little vesicles situated on a hyperaemic and painful base after a few days the vesicles become transformed into pustules and these in turn burst and dry up the whole affection lasting a week or ten days. The application of chloramphenicol cream is comforting. If the inner aspect of the lip is affected, the epithelium early becomes sodden and is shed, so that the vesicular stage is much shorter

Mucous Cysts. These are found on the inner side of the lip in the form of small rounded swellings, which are translucent and contain a glairy fluid. They are often due to trauma, whereby the opening of a mucous gland is blocked. The whole cyst wall should be dissected out, and the wound closed by stitches.

Naevi. These are frequently met with in the lip If confined to the inner aspect they may be dissected out but when large and involving the whole thickness, they should be dealt with by electrolysis or the injection of sclerosants.

Papilloma of the Lip. Papilloma and hyperkeratosis are usually seen on the lower lip especially near the angle of the mouth. The illustration shows a less common type in the mid-line of the upper lip Papilloma may simulate carcinoma, into which it may in time develop, but is distinguished by the fact that ulceration is not often present, and that there is but little infiltration of the base. Removal should always be advised.

Carcinoma of the Lip. The great majority of cases are found in middle aged or elderly men, often agricultural or outdoor workers. The lower lip and the angle of the mouth are the parts most often involved

Pathology The growth is a squamous-celled carcinoma and cell nest formation is usually well marked. It may begin as (*a*) an indurated fissure which gradually extends and ulcerates (*b*) a warty growth with early ulceration (*c*) an indurated nodule or (*d*) a thickened area of epithelium. Local extension with spread to the lymph nodes, first of the submental and submandibular regions, and later of the deep cervical group takes place relatively

slowly The nodes are at first enlarged hard and discrete, but subsequently matting is found, followed by cystic degeneration and ulceration. Visceral deposits are rare. When death occurs, it is due to fungation of the secondary growths in the neck and exhaustion from pain and sepsis, or secondary hæmorrhage from erosion of blood vessels.



FIG 29 5 CARCINOMA OF THE LOWER LIP



FIG. 29 6. CARCINOMA OF THE ANGLE OF THE MOUTH.

Diagnosis Any area of induration or infiltration of the lip should be regarded with suspicion, and in case of doubt a portion should be removed for microscopical examination. Primary chancre may cause confusion, but usually develops more rapidly with early infiltration of the nodes.

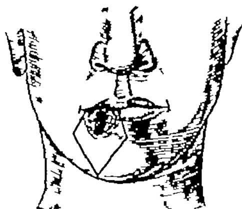


FIG. 29 7 INCISIONS FOR REMOVAL OF CARCINOMA OF THE LIP

Dark-ground examination for spirochætes and a Wassermann reaction should be performed.

Treatment The treatment of choice for carcinoma of the lip is irradiation. Low voltage X ray therapy to a dosage of about 6 000 *r* is technically simplest and gives excellent results where the growth is limited to the mucosal surface of the lip When the angle of the mouth is involved interstitial

radium needling or an applicator may be preferable Surgical treatment consists in wide excision of the primary growth, together with a part of the jaw if this is involved and the regional lymphatic areas. This operation is described on p 719

As already stated *metastatic spread occurs late and it is therefore justifiable* to adopt a " wait and see " policy with regard to nodes. If during the follow up period nodes become palpable, block dissection should be performed. If the nodes are submental all the tissues above the hyoid bone should be dissected through a wide collar incision extending to the mastoid process on each side *If the upper deep cervical nodes are unilaterally* involved, a block dissection of this side of the neck should be carried out.

THE TEETH

Dental Sepsis. There is no question about the important part played by this condition in the production of many forms of general poisoning of the system of the so-called rheumatic type Dental sepsis may also cause inflammation and abscess formation in the cervical lymph nodes. Streptococci are normal inhabitants of the mouth, and these together with various *diphtheroids, are probably responsible for most of these lesions* staphylococci are not often present. Doctors and dentists must co-operate in dealing with these affections, which play such an important part in the health of the community especially in children.

There are two main sources of absorption in connection with the teeth, *ri the apices and the gums.*

Peri-apical Infection. This occurs in about half the cases. The sequence of events is usually as follows The pulp cavity of the tooth becomes infected as a result of the extension of dental caries from the surface acute inflammatory phenomena of a purulent type, accompanied by severe toothache, end



FIG. 29 8. APICAL ABSCESSES IN CONNECTION WITH THE TEETH.

in necrosis of the pulp and when effective drainage is not provided in escape of bacteria through the *apical foramen. Inflammation is* hereby caused, and may result in the formation of a gumboil (Fig. 29 9) with relief of the pain and tension. If no gumboil forms, the process may quieten down, but an encapsulated focus remains at the apex of the tooth. If the peri-apical trouble is chronic from the first, a granulomatous nodule forms, or a small cavity lined with granulation tissue results or the bone itself is invaded, and possibly a localized necrosis follows. *From any of these local lesions general* absorption may occur The affected tooth may or may not be *tender on* pressure the pulp cavity may have been filled and yet disease may be

present, as some tiny septic focus near the apex may have been overlooked. The filling may thus have done harm rather than good.

X ray examination in all such cases is an essential for diagnosis, and the interpretation of such radiographs by an expert is very necessary since many pitfalls exist for the inexperienced (Fig. 29 8) A definite cavity or focus of necrosis around the apex of a tooth is fairly easy to recognize, but the mere existence of alveolar absorption around teeth especially in those past middle life, must not be looked on as necessarily dangerous or requiring extraction

Gingivitis This generalized condition when suppurative or ulcerative, is another source of streptococcal infection. The process often starts as a result of defective cleanliness, due to the retention of food debris between the gums and the teeth, or in the interdental spaces. Decomposition ensues, especially during the night, and inflammation is caused The gum margin becomes hyperæmic and swollen bleeding easily on pressure. Ulceration may occur on the inner or dental aspect, and from these denuded surfaces absorption can take place Diseases such as scurvy or the injudicious



FIG. 29 9 DIAGRAM OF AN ALVEOLAR ABSCESS RESULTING FROM DISEASE OF A MOLAR TOOTH.

The spread of septic material in two directions is here shown. In one, swelling forms beneath the gum in the other the spread has been medial and has burst through the palate.

administration of mercury may assist in the development of this process. The teeth become loosened, and the infection may spread along the perio-dontal membrane until possibly the teeth fall out necrosis of the alveolar margins may ensue or the suppurative process may pocket around the teeth, and finally constitute the condition of *pyorrhœa alveolaris*

It is obviously most important that all children should be carefully instructed in the correct use of tooth-brushes, as well as in the hygiene of the mouth Cleansing the mouth and teeth after meals, and especially at night should become routine in the life of a child and by the observation of a few such simple rules much sickness could be prevented

Alveolar Abscess. This is almost always associated with suppuration around the root of a carious tooth, the bacteria finding their way out of the pulp chamber through the apical foramen. The alveolar walls become expanded, and the pus either finds its way over the edge of the bone or

through the osseous tissue under the external periosteum If limited in extent, it perforates the gum directly and is then known as a *gumboil* but occasionally it burrows beneath the periosteum which is stripped from the bone, and may thus lead to an abscess of larger size possibly resulting in necrosis of the jaw The formation of an alveolar abscess is almost always associated with considerable œdema of the face and pain of a severe character The masseter muscle becomes involved in the inflammatory process with consequent trismus or difficulty in opening the mouth Sometimes graver complications ensue thus in the upper jaw the antrum may be infected and suppuration in this cavity follow while in the lower the abscess may travel downwards and burst externally either close to the lower margin of the bone or in the neck. A troublesome sinus results, which can only be cured by the removal of the tooth, and even then a depressed and adherent cicatrix ensues, which is very unsightly The essential point in the treatment consists in the removal of the offending tooth

Odontomes. *These are cystic or solid "tumours" arising in connection with the teeth* There are two main types and several less important varieties

Epithelial (*Fibrocystic Disease*) This type is derived from remnants of the enamel organ, and is usually found in individuals about the age of



FIG. 29 10. SPECIMEN OF EPITHELIAL ODONTOME OF THE LOWER JAW (*R. C. S. Museum.*)

twenty years, occurring ten times more frequently in the lower jaw than in the upper It forms a tumour often of large size and reddish in parts, which on section consists of large numbers of small cysts containing mucoid fluid, *separated by fibrous or osseous septa.* Microscopically the cysts are lined by cubical or columnar epithelium. The more solid *adamantinoma* is probably of similar origin Treatment consists in radical extirpation of the affected portion of the jaw followed if necessary by bone grafting. Less extensive operations may succeed in some cases.

Follicular (*Dentigerous Cyst*). This arises from the dental sac around an unerupted tooth, and causes expansion of the jaw At first the tumour is hard and solid later egg-shell crackling and fluctuation may be detected and in some cases, owing to infection from a neighbouring tooth, a sinus may form, discharging pus. It may be found in the upper or lower jaw more commonly the latter and in the molar region it usually but not invariably affects *young people.*

Other odontomes are all rare. The *fibrous* type (though common in

animals) is seldom seen an unerupted tooth lies in dense fibrous tissue. A *cementome* consists of a calcified dental sac. A *compound follicular* odontome consists of a number of fused dentigenous cysts so that the cavity contains several badly formed teeth. The *composite* type is often large and very hard, resembling an ivory osteoma except that it is easily shelled-out from the jaw It consists of enamel, dentine and cementum The *radicular* odontome is small, grows only from a root and therefore contains no enamel.

In most cases the diagnosis can be made by noting the associated absence of one or more permanent teeth, or the persistence of the milk teeth. Skiagrams may disclose an unerupted tooth embedded in the swelling.

Dental Cysts. These are not uncommon and are always associated with dental caries. They are more often seen in the upper jaw in relation to the premolar or molar teeth. A large dental cyst in the lower jaw which has



FIG 29 11 DENTAL CYST

also caused a pathological fracture is illustrated. They develop at the roots of the teeth, causing a painless regular expansion of the bone, free from inflammatory phenomena, unless infected secondarily with bacteria. After a time the centre of the swelling softens, and as the bony wall is absorbed, parchment like crackling can be felt finally the condition presents as a rounded, tense, elastic swelling, around the margins of which the remains of the expanded bone can be detected. In the upper jaw a cyst often encroaches on and projects into the antral cavity pushing the mucous membrane in front of it. The tooth which is the cause of the trouble is always dead, and frequently merely a septic root is present.

The cause of the condition is the septic tooth and this is in effect a chronic alveolar abscess. It has to be distinguished from an epithelial odontome which arises from the remnants of the enamel organ In addition dental cysts may arise as a local manifestation of generalized bone disease due to

hyperparathyroidism radiography of other parts of the skeleton especially the phalanges, is helpful in providing the diagnosis which is confirmed on finding a raised serum calcium Treatment is then directed at the parathyroids and not the cysts

Treatment The cyst must be freely opened into the mouth the septic tooth or stump removed, and the anterior wall of the alveolus cut away The alveolus and cyst thus laid into one cavity are scraped so as to remove all the epithelial lining, and packed with gauze so as to ensure healing by granulation In the upper jaw the utmost gentleness is required in dealing with the deeper wall of the cyst, as the septum between it and the antral cavity may be extremely thin and entirely devoid of bony tissue If the cyst bulges into the maxillary sinus it must be obliterated by an approach through the canine fossa as in the Caldwell-Luc operation.

The Extraction of Teeth. Although this operation is usually undertaken by dentists, yet any medical practitioner may have to perform it. An anæsthetic may or may not be employed local analgesia should be avoided in the presence of sepsis. The posterior teeth are dealt with first, and subsequently those in front. Suitable forceps are required for the various teeth, and the number of roots belonging to each much be kept in mind. Incisor and canine teeth are removed by a combination of traction and rotation the premolars and molars by traction combined with lateral movement, especially inwards The forceps, after being sterilized, should be pushed well up under the gum, and no traction made until a firm grasp has been taken of the neck of the tooth and the tooth itself loosened by lateral swaying.

Accidents of various types happen from time to time. The crown may break away leaving the roots *in situ* and then each of these must be sought with root forceps and accounted for In dealing with the first or second upper molar it is quite possible to drive a root upwards into the antral cavity setting up thereby suppuration within the cavity Laceration of the gum is often unavoidable and injury to the alveolar margin may follow but such accidents as fracture or dislocation of the lower jaw are certainly avoidable. The use of an elevator is sometimes desirable in order to remove old roots, but it is an instrument that must be used with great care.

Should the hæmorrhage continue, as in patients suffering from purpura, scurvy or hæmophilia, the socket must be carefully plugged with a strip of gauze soaked in a styptic such as 1 in 1,000 adrenaline or hæmostatic gauze. Plugging is frequently a difficult and unsatisfactory method as an alternative the walls of the socket may be approximated with a catgut suture, which effectively prevents further bleeding. This method is obviously not applied where an abscess is draining through the socket.

Wisdom Teeth These often cause trouble owing to abnormal eruption, both as to date and manner The most common condition is for the wisdom tooth to be wedged against the second molar in such a position that its eruption is impossible. Inflammatory phenomena usually follow or trismus, and it becomes essential to relieve the condition. The offending tooth is generally so deeply buried that even under a general anæsthetic it is difficult to reach it, and the alternative is to remove the second molar when normal eruption may quickly follow and the wisdom tooth take on the work of the second molar In the hands of the expert, however it is usually possible to remove the offending third molar leaving the second molar intact.

THE GUMS AND ALVEOLAR PROCESSES

Hypertrophy of the Gums. This is encountered as a sessile overgrowth, sometimes almost cauliflower-like, around and between the teeth, which are usually carious it occurs most frequently in children If slight, the overgrowth may be destroyed by the application of a crystal of trichloracetic acid, but in the more exaggerated types excision is required.

Epulis. By this term is meant a tumour growing from the alveolar periosteum. Two varieties are described, *viz* the simple and the so-called myeloid which is in reality an osteoclastoma

Simple Epulis This is usually of a fibromatous nature and may grow from either jaw though more commonly from the lower It is generally due to the irritation of diseased teeth and although most marked on the outer aspect, it burrows between the teeth, and is also found on the inner side It appears as a red fleshy mass, smooth or perhaps lobulated of an elastic consistence and possibly associated with a little superficial ulceration. It is covered with mucous membrane and may contain a few spicules of bone. The treatment consists in removing the growth, together with the

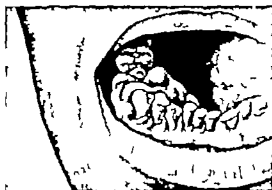


FIG. 29 12. SIMPLE EPULIS.

teeth or stumps with which it is connected If small it will suffice to cut away and scrape the bone from which it arises but if large or if it recurs after such treatment, the portion of the alveolus from which it springs must also be excised. This is best accomplished by extracting a tooth on either side of the tumour and cutting vertically through each socket with a saw the two incisions being united below by a chisel, so as to remove a quadrangular portion of bone without interfering with the continuity of the jaw

Osteoclastoma Myeloid or giant-celled epulis are other names for this condition which is in fact a relatively benign primary tumour of bone arising within the alveolar process. The histology is identical with osteoclastomata elsewhere. Hyperparathyroidism may produce a lesion in the mandible identical with an osteoclastoma. Where the tumour remains entirely encapsulated it presents the usual signs of this tumour—a smooth regular swelling, with eggshell crackling on palpation in some cases. It forms a soft, rapidly increasing mass of a dusky purple colour which runs on to ulceration or fungation the deeper portions may contain an ossific deposit. Treatment consists in free removal of the tumour and of the portion of alveolus from which it arises. In the upper jaw this sometimes necessitates

excision of the complete palatal segment of the maxilla but in the lower jaw it is generally possible to maintain the continuity of the mandible by removing merely a quadrilateral portion in the same way as for a simple epulis. Operation should always be combined with irradiation

Malignant Neoplasms. Squamous-celled *carcinoma arises most often* from the mucosa of the lower alveolus and soon infiltrates the bone In the upper jaw extension into the antrum may follow The varieties of growth are similar to those described on the lip (*i.e* ulcer indurated plaque proliferating mass) and the same groups of regional lymph nodes are involved but more rapidly *Sarcoma* round and spindle-celled occurs rarely

The treatment of cancer of the buccal cavity is considered in Chapter 30

THE JAWS

Fractures of the Maxilla and Mandible. A description of these fractures and of dislocation of the lower jaw will be found in Chapter 40

Necrosis of the Jaws. *Ætiology* This condition has become less common in recent years owing to improvement in dental hygiene and the removal of some of the specific causes. The following causes are described (*a*) Subperiosteal *alveolar abscess* connected with dental caries. (*b*) *Trauma* such as blows on the jaw with or without fracture, in the latter instance being due



FIG. 29 13 LOWER JAW SHOWING PHOSPHORUS NECROSIS, FROM A MAN, AGED 35 WHO HAD BEEN ENGAGED IN LUCIFER-MATCH MAKING FOR MANY YEARS (*R.C.S. Museum.*)

to infective osteitis. The use of dirty forceps or elevators in extracting a tooth may similarly lead to inflammation, resulting in necrosis. (*c*) It may follow one of the *exanthemata* or any condition of *malnutrition*, arising as an embolic osteomyelitis and then probably affecting a considerable extent of bony tissue, possibly the whole mandible. (*d*) It results from *mercurial poisoning* but rarely at the present day (*e*) *Phosphorus* necrosis was met with amongst those who worked in lucifer-match factories, but only when yellow phosphorus was used the amorphous form is harmless. The fumes are supposed to gain access to the jaws through carious teeth, giving rise to a somewhat acute inflammation, which terminates in necrosis. A considerable amount of new bone forms beneath the periosteum and the sequestrum, which is curiously grey and porous, like pumice-stone, is always slow in separating. Either jaw may be affected, but the lower a little more commonly than the upper (*f*) *Tubercle* and *actinomycosis* are occasionally

bone inside the mouth and along the line of reflection of the mucous membrane. When necrosis is present it must be treated in the ordinary way the sinuses being flushed out with an antiseptic solution three or four times a day until the sequestrum is loose It is then removed, if possible from within the mouth. Drainage by means of an external opening is often absolutely necessary Penicillin should be given in full therapeutic doses for several weeks and especially as a prophylactic measure before any dental extractions are performed if a patient has had any irradiation therapy to the mouth, face or neck.

Atrophy of the Jaws. This condition, though affecting both jaws, is more commonly seen in the mandible This may be considered as a mixed bone because it is formed chiefly from membrane, but also from cartilage. At birth it consists of two halves, connected at the symphysis menti by fibrous tissue The rami are short, so that each condyle is nearly on a level with the upper border of the symphysis. During the first year osseous union takes place. As adult life is reached the body of the mandible increases in depth, the rami lengthen and the angle decreases. The mental foramen gradually assumes a position midway between the superior and inferior borders. In old age, if the bone becomes edentulous the whole of the alveolar border undergoes absorption. If teeth are extracted in adult life, the alveolar margin becomes absorbed, as can be seen in Fig. 29 14

Osteomyelitis of the Jaws. Necrosis has already been described but in addition osteomyelitis of the same sort as affects the long bones may occur The acute form is very severe, but fortunately is rarely seen. The infection



FIG. 29 15 OSTEOMYELITIS OF THE LOWER JAW SHOWING SEQUESTRUM.

may be blood borne, or it may reach the bone from an adjacent infection in the teeth. As the lower jaw obtains its blood-supply internally from the inferior dental artery and externally from vessels supplying the periosteum, it can be imagined that various forms of disease exist according to the source of the infection. The whole of the marrow cavity is supplied by the inferior dental artery which is enclosed in a dense canal, and if this artery is occluded by septic thrombosis, there is destruction of a large part of the lower jaw As a rule the whole of the alveolar process, carrying with it the teeth, may necrose and become separated. Sometimes, a week or so after one side of the jaw becomes infected, the other side follows suit.

In those cases where the disease is caused by extension of infection from the mouth, either from an infected tooth or from an injury there may be a much more severe reaction owing to the fact that the infection is not due

responsible for this condition and in tertiary *syphilis* it is observed, usually affecting the alveolar borders of the palate. (*g*) *Irradiation* necrosis. This is a form of necrosis which has appeared with the advent of radium treatment for cases of carcinoma of the tongue. It is probably the most chronic and most painful form of necrosis which affects the lower jaw. It is preventable to a large extent by careful technique. Cases do arise, however where every precaution has been taken and the necrosis which is heralded by chronic burning pain, often for a month or more, becomes manifest firstly by X-rays before any clinical signs are forthcoming. Months pass before any clinical evidence of necrosis is to be seen, and sequestra slowly form and take a very long time to separate. Two or three years is often the actual time period for the separation of minute sequestra. In this condition again, conservatism is the treatment, any active intervention causing a mixed infection and an osteomyelitis of the mandible. The condition can be caused by extraction of teeth following irradiation to the mouth.

Clinical Appearances. Those associated with necrosis are necessarily much the same whatever the cause. The acute form commences with severe pain in and around the jaw followed by great swelling of the face and

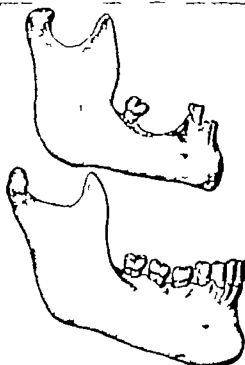


FIG. 29 14. TWO JAWS FROM PEOPLE OF THE SAME AGE.
The upper one shows how the alveolar margin atrophies on removal of the teeth.

difficulty in opening the mouth or taking food. The temperature is raised, rigors may be present, the breath is usually foul. Sooner or later an abscess forms, which may point either in the mouth or on the face, or the pus may burrow downwards for some distance into the neck.

Treatment. In the early stage the cheek should be fomented, but as soon as there is any suspicion of pus a free incision is made down to the

bone inside the mouth and along the line of reflection of the mucous membrane. When necrosis is present it must be treated in the ordinary way the sinuses being flushed out with an antiseptic solution three or four times a day until the sequestrum is loose it is then removed if possible from within the mouth. Drainage by means of an external opening is often absolutely necessary Penicillin should be given in full therapeutic doses for several weeks, and especially as a prophylactic measure before any dental extractions are performed if a patient has had any irradiation therapy to the mouth, face or neck.

Atrophy of the Jaws. This condition though affecting both jaws is more commonly seen in the mandible. This may be considered as a mixed bone, because it is formed chiefly from membrane but also from cartilage. At birth it consists of two halves, connected at the symphysis menti by fibrous tissue The rami are short, so that each condyle is nearly on a level with the upper border of the symphysis During the first year osseous union takes place. As adult life is reached, the body of the mandible increases in depth, the rami lengthen and the angle decreases. The mental foramen gradually assumes a position midway between the superior and inferior borders. In old age, if the bone becomes edentulous, the whole of the alveolar border undergoes absorption. If teeth are extracted in adult life, the alveolar margin becomes absorbed, as can be seen in Fig. 29 14

Osteomyelitis of the Jaws. Necrosis has already been described but in addition osteomyelitis of the same sort as affects the long bones may occur The acute form is very severe but fortunately is rarely seen The infection



FIG 29 15 OSTEOMYELITIS OF THE LOWER JAW SHOWING SEQUESTRUM.

may be blood borne, or it may reach the bone from an adjacent infection in the teeth. As the lower jaw obtains its blood-supply internally from the inferior dental artery and externally from vessels supplying the periosteum, it can be imagined that various forms of disease exist according to the source of the infection. The whole of the marrow cavity is supplied by the inferior dental artery which is enclosed in a dense canal, and if this artery is occluded by septic thrombosis, there is destruction of a large part of the lower jaw As a rule the whole of the alveolar process, carrying with it the teeth, may necrose and become separated. Sometimes a week or so after one side of the jaw becomes infected the other side follows suit.

In those cases where the disease is caused by extension of infection from the mouth, either from an infected tooth or from an injury there may be a much more severe reaction owing to the fact that the infection is not due

solely to the *Staphylococcus aureus* but to a mixed infection in which a variety of organisms take part. In such cases extensive suppuration of the soft tissues of the neck may arise and there may be extension down the fascial planes of the neck into the mediastinum.

Treatment This should be mainly conservative Penicillin and sulphonamide are given in full therapeutic doses It may be necessary to incise the periosteum and drill the bone. Owing to the density of the osseus tissue of the lower jaw it takes a long while for the necrotic bone to become extruded—much longer in fact, than in the long bones. It may take several months, or even years before all the sequestra finally become separated.

Actinomycosis of the Jaw The lower jaw is one of the sites infected with the ray fungus, the infection starting in a carious tooth, or an abrasion of the mucous membrane by a tooth plate or a hard particle of food. There is some swelling of the bone which eventually leads to necrosis. Multiple abscesses form which in turn form sinuses, and these discharge sticky exudate containing the well known granules." Excessive fibrosis takes place about the sinuses and the tissues appear to be markedly indurated. If the disease is not treated, slow extension takes place into the muscles in the neighbourhood, and the jaw may become fixed, causing difficulty in swallowing and breathing. The veins may be compressed, or occasionally erosion takes place with generalized metastatic spread of the disease.

Treatment This is local and general. Surgery is limited to the opening of abscesses and the removal of sequestra when they appear

General treatment consists of large doses of penicillin Half a million *units daily for three months is a satisfactory course Iodine is effective* as Lugol's solution or potassium iodide Small doses 5–10 mm (0 3–0·6 ml.) of tincture of iodine t.d.s. appear to be as effective as large doses. The treatment should extend over six weeks or two months. X ray treatment has given good results in some cases.

Osteitis Deformans (*Paget s Disease*) Although the bones of the cranium are commonly affected by this disease, the upper and lower jaws only show slight involvement. Very rarely a case is recorded where the lower jaw is markedly enlarged Skiagrams show cystic spaces in the bone connected by multiple trabeculæ throughout the entire length The dried bone is quite porous.

Neoplasms of the Jaws

Leontiasis Ossea. There has been a great deal of argument about the nature of this rare, progressive and disfiguring disease It was at one time thought to be a low-grade inflammatory condition originating in the ethmoid cells and spreading as a creeping periostitis to involve the facial bones and mandible It is now recognized that if general skeletal diseases such as osteitis fibrosa and Paget s disease and chronic pyogenic osteitis or syphilitic osteitis can be excluded then the true leontiasis can be regarded as a diffuse osteoma, that is to say an innocent bone neoplasm

Clinical Features The disease commences in young adult life progresses relentlessly and may eventually destroy the patient after causing much suffering. It affects the cranial and facial bones and frequently the lower jaw also The bones are sclerosed or spongy in places, pitted and projections form which give the patient a repulsive appearance As growth progresses the new bone encroaches upon the cavities of the cranium the orbits, antra

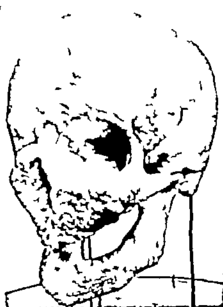


FIG. 29 16. LEONTIASIS OSSEA. (*R.C.S. Museum.*)

and mouth. Exophthalmos and neuralgia result. The extraction of teeth, which may be necessary can be exceptionally difficult.

Treatment No treatment is of much avail though small doses of X rays



FIG. 29 17 LEONTIASIS OSSEA AFFECTING THE LOWER JAW OF A WOMAN AGED 31



FIG. 29 18. SKIAGRAM OF THE SAME PATIENT

may perhaps delay the spread of the disease. Infection can be benefited by the use of antibiotics.

Osteitis Fibrosa. As stated above this disease, when affecting the jaws, may be clinically indistinguishable from leontiasis ossea. It is, however

always associated with an adenoma of the parathyroid gland and a raised serum calcium. A general description of the disease is given in Chapter 18.

Innocent Tumours. *Osteoma* This occurs in either jaw and in two forms, the cancellous osteoma and the ivory osteoma Both, however are more common in the mandible. The cancellous form grows in the ramus of the bone while the ivory osteoma is found near the neck or condyle. Growth is slow but may interfere with mastication. Removal presents some difficulties and also the risk of fracturing the jaw

Other benign growths include *chondroma* subperiosteal *lipoma*, the ossifying *fibroma* and *myxoma* which are probably degenerative forms of the preceding tumours These growths are distinguished from malignant tumours by the length of the history smooth and circumscribed outlines and skiagraphic appearances which do not suggest invasion or destruction of bone The treatment in most cases is excision

Osteoclastoma. This is described under the heading of epulis on p. 712. Osteoclastoma is not strictly an innocent tumour for although it does not metastasize in the manner of sarcoma, it nevertheless shows a distinct tendency towards local recurrence.

Malignant Neoplasms of the Upper Jaw Since these growths are clinically and therapeutically associated with the nose and paranasal sinuses they are described in Chapter 31 which covers this field Both squamous-celled carcinoma and osteogenic sarcoma occur in the upper jaw

Sarcoma of the Mandible. *Osteogenic sarcoma occurs in the younger* age groups—children and young adults. Histologically it may be round- or spindle-celled or take the form of fibrosarcoma or myxochondrosarcoma. It may be periosteal or endosteal and be osteolytic or osteoplastic the latter is unusual. But all are varieties of the same disease and all are very malignant.

Clinical Features Pain is an early symptom, followed by swelling of the face and inside the mouth, extrusion of teeth, sepsis and ulceration. The skin overlying the jaw is hot and red and the condition may be mistaken for osteomyelitis. The skiagraphic appearances vary but usually irregular bone destruction (without areas of sclerosis, as in osteomyelitis) is the main feature. As with osteogenic sarcoma elsewhere, *blood borne metastases*, especially to the lungs, are common.

Treatment This is disappointing. Surgical excision may be possible but often only radiotherapy is practicable. Although some growths are radio-sensitive early recurrence is the rule.

Ewing's Tumour A small number of cases of Ewing's tumour also called endothelioma of bone, occurring in the jaws have been described. Though there is doubt as to whether this is a primary bone neoplasm or a secondary deposit of an adrenal neuroblastoma the clinical picture is usually distinct. In the jaw however the characteristic onion-skin lamellæ of the cortical bone are not seen.

Melanoma. *This highly malignant tumour occurs rarely in the jaw or* alveolar process. Wide excision is required

Carcinoma. The lower jaw is often directly invaded by growths of the tongue floor of mouth or faucial regions also and at an early stage, in carcinoma arising from the mucosa of the alveolar process. Wide excision of the bone in continuity with the primary is required but is not always practicable especially in faucial growths.



FIG. 29 19 OSTEOGENIC SARCOMA OF THE LOWER JAW



FIG. 29 20. SKIAGRAM OF THE SAME PATIENT



FIG 29 21 SARCOMA OF THE LOWER JAW IN A CHILD

Excision of the Lower Jaw Total mandibulectomy is seldom performed. Partial excision may be necessary in the removal of an epulis this consists generally of the removal of a portion of the alveolar border together with the growth. Resection of the median portion of the lower jaw is undertaken for those cases where there has been an extension from a carcinoma of the under surface of the anterior part of the tongue, from a carcinoma of the floor of the mouth, or even from a carcinoma of the lip

Hemi-mandibulectomy is necessary in many cases of malignant disease and in a few cases of necrosis of the jaw Endotracheal gas and oxygen anæsthesia and packing of the pharynx with gauze is imperative. With the head turned to the opposite side, an incision is made commencing in the centre of the lower lip and passing downwards to a point immediately below the symphysis. It is then carried along the under surface of the body of the

mandible and as far as the angle. The incision is then prolonged upwards along the posterior border of the vertical ramus as far as the lobule of the ear but no further because of the danger of cutting the facial nerve. Alternatively the incision may start at the angle of the mouth as indicated by a dotted line in the figure. While making the incision over the posterior part of the body of the mandible the facial vessels are encountered and secured between ligatures The large flap is turned upwards, and the muscles attached

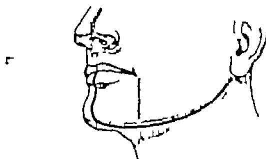


FIG 29 22. THE INCISION FOR REMOVAL OF HALF THE LOWER JAW

to the jaw which are not involved or in contact with the tumour are elevated by a periosteal elevator The muscles on the inner side of the jaw are dealt with in a similar manner care being taken that the mucous membrane of the mouth is kept intact. The central incisor tooth is extracted, and the jaw divided through the empty socket with a Gigli saw a little to one side

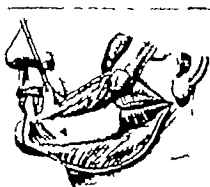


FIG. 29 23 OPERATION FOR REMOVAL OF HALF THE LOWER JAW
The skin flap is raised and the masseter muscle cut through.



FIG 29 24 EXCISION OF HALF THE LOWER JAW
The bone has been divided in the midline and its final muscular attachments are severed.

of the middle line By this means the genial tubercles and their attached muscles are not damaged, and so the movements of the tongue are unimpaired. The bone is now pulled outwards, and its internal attachments are brought into view and divided care being taken to secure the inferior dental vessels just before they enter the canal in the bone By depressing the jaw the tendon of the temporal muscles is exposed and its attachment to the coronoid process can be severed by a few touches with the knife. Lastly the condyle of the jaw is freed after cutting through the tendon of the external pterygoid muscle and the capsule of the temporomandibular

joint. Care should be taken not to divide the internal maxillary artery which is in close proximity to the inner surface of the neck of the mandible. As a rule hæmorrhage is quite easily controlled and the wound can be stitched together with interrupted silkworm-gut sutures a drainage tube being inserted at the posterior end Care should be taken in approximation of the lip so that the red margin is continuous on both sides of the incision

The wound heals well and there is surprisingly little deformity from this operation Inevitably the opposite side of the mandible is drawn across the midline and this makes the fitting of a denture unsatisfactory Lengthy plastic repair with the introduction of a new jaw made either from the iliac crest, bone chips or an acrylic prosthesis may be undertaken at a later date But in cases of malignant disease there is much to be said for not interfering further with tissues which have very likely been heavily irradiated

The Temporomandibular Joint

Acute Synovitis and Arthritis. *Acute Synovitis* This may occur during the course of an attack of rheumatic fever and is evidenced by pain on movement of the jaw and by tenderness and swelling immediately beneath the root of the zygoma, due to effusion into and around the joint. Resolution generally follows, but fibroid thickening of the ligaments and impairment of movement may result.

Acute Arthritis This follows pyæmic infection after the exanthemata, or from gonorrhœa but may be caused in children by direct extension of inflammation through the tympanic plate from the middle ear as in scarlatina. It is characterized by the usual signs of a severe localized inflammation with the formation of abscesses, and results commonly in ankylosis. Treatment with penicillin and sulphonamides should be begun at the earliest opportunity Fomentation may be applied to the side of the head and if pus forms the joint will require drainage. Excision of the condyle may be required later

Osteo-arthritis. This condition is not at all rare although it is quite often overlooked as a cause of pain in the joint. With modern methods of radiology the condition can be seen quite easily on a skiagram The condition may be symmetrical and is characterized by considerable enlargement of the condyle of the jaw which causes it to bulge laterally so that it can be felt in front of the tragus of the ear Movements of the joint are painful and limited, and crepitus can nearly always be elicited. If the condition is bilateral, the lower jaw appears to be pushed forwards, rendering the chin prominent. If however the condition is unilateral, the jaw becomes deflected to the sound side. Loose bodies may form in some cases, and may cause "locking" of the joint, while in others there is extensive lipping of the periphery of the condylar cartilage proliferation of the synovial villi, and "lipoma arborescens" may develop As the disease progresses the interarticular cartilage may disappear completely and the glenoid cavity as it enlarges, may assume a flattened outline, so that a partial dislocation may occur If pain and limitation of movement are complained of the only satisfactory treatment is excision of the condyle as all other forms of treatment are ineffective

The operation of excision of the condyle of the jaw is carried out through a curvilinear incision, commencing over the middle of the zygoma, and passing downwards in front of the tragus. In this operation the surgeon

is working in a somewhat cramped space with the zygoma above, the facial nerve below the parotid gland in front, and the external ear behind After the skin and subcutaneous tissues have been incised the small flap is turned upwards A transverse incision is now made at the posterior end of the zygoma, opening up the capsule of the joint and the synovial membrane. The neck of the mandible is exposed and a fine Gigli saw is passed round this with a small aneurysm needle The neck of the bone is cut through with this saw and the condyle removed. Sometimes the neck of bone may be divided with a small pair of bone cutters. Any bleeding from the cut surface of the bone can be controlled by the firm application of some bone wax to the raw area. A piece of fascia or a strip of the masseter muscle (Fig. 29 25) can be placed over the cut surface of the bone and retained with a stitch. This prevents any chance of ankylosis of the joint. The wound is

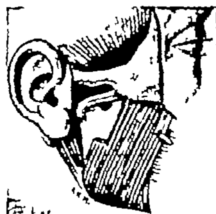


Fig 29 25 Drawing showing how a Strip of the Masseter Muscle may be Used to Ensure a False Joint after Excision of the Condyle.



Fig. 29 26. Displacement of the Mandibular Cartilage.

closed with two or three interrupted sutures, no drainage being employed. The patient is encouraged to move the joint at an early date.

Clicking Jaw This condition is in reality an internal derangement of the joint due to laxity of the attachment of the interarticular cartilage, which gets caught between the condyle and the eminentia articularis when the mouth is opened. The effect is a temporary painful fixation or locking of the jaw which is usually set free by lateral movements. At other times there is marked clicking or creaking of the jaw when the mouth is opened. The actual displacement of the mandibular cartilage is probably due mainly to the shape and attachment of this meniscus The fibrocartilage is a dome-like structure very closely applied to the convexity of the mandibular condyle As far as thickness is concerned it is irregular being very much thicker in its centre and anteriorly between these two thickenings there is a distinct depression. The posterior part of the cartilage is very thin and passes well down over the posterior surface of the condyle and fuses behind with the capsule. Rarely the posterior part of the mandibular cartilage actually becomes detached and is pulled forwards (Fig. 29 26) In troublesome cases treatment consists in excising the loose cartilage through a T-shaped incision. Manipulation with wide opening of the mouth may sometimes relieve the symptoms.

Tuberculous Arthritis. It is often difficult to be certain whether tuberculous disease in this joint has arisen in the bone or in the synovial membrane. The affection itself is rare and is only seen when the disease is fairly well advanced It runs the usual course of any tuberculous joint affection and ends in caries of the condyle. Secondary infection may occur leading to ankylosis The condition is very chronic, and has been mistaken for osteo-arthritis on more than one occasion the true diagnosis only being made when excision of the condyle was performed and the bone subjected to microscopical examination Excision of the condyle is the treatment for this condition if it will not respond to conservative measures.

Ankylosis of the Jaw Ankylosis may be fibrous or bony and due to any of the foregoing causes. Fibrous ankylosis may be treated by manipulation or injections of hydrocortisone If severe enough excision of the condyle must be considered Bony ankylosis is treated by operation in the



FIG. 29 27 BONY ANKYLOSIS OF THE JAW OF MANY YEARS STANDING. (*R.C.S. Museum.*)



FIG. 29 28. THE EXTENT OF BONE REMOVED IN EXCISION OF THE CONDYLE AND IN ESMARCH'S OPERATION.

manner described for excision of the condyle though much more bone requires to be removed. A fine pair of nibbling forceps will be found more useful than a Gigli saw the neck and head of the mandible being carefully removed piece by piece, until a gap of about 1 cm. is made.

The most difficult cases to relieve or cure are those in which there is much cicatricial contraction round about the joint. Division or excision of the adhesions is useless, as during healing, fresh adhesions form and the condition is unrelieved. In these cases, therefore, Esmarch's operation often gives good results (Fig. 29 28) This operation consists of the removal of a wedge of bone, with its apex towards the alveolar border from the neighbourhood of the angle of the mandible A portion of the detached masseter muscle is turned in between the two bony surfaces so that an artificial joint is formed. The incision should be made below and behind the angle of the jaw this gives good exposure and allows the muscles to be separated from the outer and inner surfaces of the mandible. The bone can most conveniently be divided by the use of a Gigli saw An alternative method is to remove the vertical ramus of the jaw down to the level of the alveolus, but this method does not give so satisfactory a result as Esmarch's operation

Chapter 30

THE MOUTH AND SALIVARY GLANDS

Stomatitis

Inflammation of the mucous membrane of the mouth is by no means uncommon, especially in children.

Catarrhal Stomatitis. This results from mechanical irritants, *e.g.* roughened teeth, irritating chemicals, or from inflammation following operations which involve the mouth, and is undoubtedly increased, if not initiated, by excessive smoking. It also arises in the course of fevers, and in conditions of debility such as follow measles and other exanthemata in children or is associated with disturbances in the alimentary canal, as from improper feeding, dyspepsia, etc. The mucous membrane becomes hyperaemic and swollen, usually in small localized patches, which may gradually spread and become confluent, involving nearly the whole of the oral cavity The exudation of mucus is increased and becomes viscid and turbid while the epithelium, at first white and sodden is after a while rubbed off, leaving superficial erosions or distinct ulcers which are very painful The treatment consists in the removal of all sources of irritation, and the correction of dyspepsia, if present. Antiseptic or astringent mouth-washes should also be employed.

Aphthous Stomatitis. This occurs in badly fed children in the form of small whitish spots on a hyperaemic base, which run together and produce ulceration. Attention is first directed to feeding and to improving the general condition of the baby The local condition is treated by the application of 1 per cent. gentian violet. *Thrush* is due to the presence of a parasitic fungus the *Oidium albicans* and occurs in patches somewhat resembling curdled milk in appearance. In history and treatment it resembles the aphthous variety In both types there is often some enlargement of the lymph nodes, which, however frequently subside without suppuration.

Gangrenous Stomatitis. Cancrum oris is now a rare condition in this country only affecting young children who are severely undernourished. The process starts from an abrasion in the mucous membrane which being infected perhaps from a diseased or dirty tooth becomes inflamed and gangrenous A similar condition occurs rarely in elderly debilitated people, especially if suffering from nephritis or diabetes and in the possessors of foul teeth.

Mercurial Stomatitis. This is rarely seen, except in persons who are unduly sensitive to the action of mercury It is aggravated by dirty teeth, or if the patient smokes to excess The gums are swollen and tender bleed on pressure and are very painful especially when biting or drinking hot fluids. The teeth may become loose and fall out, while the alveolar borders may be laid bare and necrose. The tongue is sometimes swollen and inflamed, salivation is a marked symptom and the breath becomes very

offensive The administration of mercury should be stopped and saline purges given Potassium chlorate combined with alum dilute hydrochloric acid or tincture of myrrh, may be useful locally

The buccal mucous membrane is also involved in the course of other diseases, e g diphtheria scarlet fever syphilis and erysipelas Ulceration of the mouth and faucial region also occurs in agranulocytosis and in acute leukæmia.

Vincent s Angina. Small deep linear ulcers may occur on the buccal mucosa or lateral border of the tongue and are often caused by a jagged tooth. The organisms responsible are the *Bacillus fusiformis* and Vincent s spirillum. The appearance is characteristic, the edge of the cleft being bright red and the base being covered by a yellow slough Both organisms are sensitive to penicillin or to injections of N.A B The offending tooth must of course be dealt with

THE TONGUE

Congenital Abnormalities. *Absence* The tongue is completely or partially absent. This condition is extremely rare

Hemiatrophy One half of the tongue is defective in size

Tongue-tie This is said to be present when the frænum is shorter than usual, causing the tip to be depressed and fixed in the floor of the mouth so that it cannot be protruded. Sucking becomes difficult and when such a condition is allowed to persist there is often a lisp in the speech Treatment is only needed in the severer forms, and consists in raising the tongue with the index and middle fingers placed one on either side and snipping the frænum, thus put on the stretch across its centre with a pair of blunt pointed scissors directed downwards.

Ankyloglossia The tongue may be adherent to the floor of the mouth, being bound down by folds of mucous membrane This may also exist as an acquired condition due to cicatricial contraction after ulceration In congenital cases the adhesions are slight, and the organ can be readily freed in the acquired condition this cannot always be accomplished

Mobility The frænum and tongue are occasionally too long, allowing increased mobility Fatal results may occur from the organ rolling backwards and impeding respiration. Treatment is transfixion of the tip of the tongue by a stitch which is secured to the chin with adhesive tape.

Cleft Tongue The tongue may be cleft, presenting a bifid appearance this may be complete or partial, and is usually associated with a congenital fissure through the lower lip and mandible.

Macroglossia A large tongue, although sometimes acquired, is usually a congenital deformity The organ is enlarged in all directions, and protrudes from the mouth, so that the teeth indent it and cause ulceration and considerable interference with the venous return. It thus becomes purplish and dry from exposure, the mucous membrane looking almost like skin, although saliva dribbles freely from beneath it. In old-standing cases the teeth are displaced outwards and the jaws deformed, so that, even if the tongue is reduced to its normal size by treatment it may be impossible to close the mouth. Histologically the appearances are those of a *lymphangioma* but associated with diffuse overgrowth of connective tissue. Recurrent attacks of lymphangitis add to the trouble, the tongue gradually increasing in size and the disease has been known to terminate in the development of lympho-

sarcoma. The treatment consists in excision of a V-shaped portion, suturing the raw surfaces subsequently with catgut. Alternatively radium or radon needles implanted in the tongue satisfactorily reduce its size. In some cases *macroglossia* is an evidence of hypothyroidism and is typically seen in cretins and in myxœdema cure usually follows the use of thyroid extract.

Hæmangioma This may also occur and requires treatment by excision, coagulation or irradiation

Wounds of the Tongue. *These are usually caused by the teeth, especially* in children, either during an epileptic fit or as a result of falls. There is often brisk hæmorrhage for a few moments, but the blood may be extravasated into its substance, and causes considerable swelling. In simple cases the wound should be cleaned and a few catgut sutures inserted. *But the wound* must not be entirely closed, or tension from infection will result. When brisk arterial bleeding is present, the wounded vessel must be sought for and tied.

Acute Superficial Glossitis. This occurs as part of a general stomatitis.

Acute Parenchymatous Glossitis. Acute inflammation of the tongue may arise from penetrating and infected wounds, or from the bites or stings of insects, or may be associated with acute stomatitis in the course of fevers, or with the injudicious administration of mercury The condition may be limited to one half of the organ, but when arising from general causes it is bilateral. The tongue becomes painful, swells up rapidly so as to fill the mouth, and even protrudes beyond the teeth, the pressure of which leads to superficial ulceration The salivary glands are enlarged, painful, and salivation is a marked feature Speech, swallowing and even respiration are much interfered with, and there may be considerable febrile disturbance. Suppuration may ensue as well as the most urgent dyspnœa, arising either from œdema of the glottis or from the pressure of the enlarged organ.

Treatment *Penicillin and sulphadimidine should be given in* full doses. Ice may be sucked to give some relief If obstruction of the glottis threatens, tracheotomy should be performed or an endotracheal tube passed through the nose. Incision may be necessary if suppuration occurs.

Abscess of the Tongue. This may result from the acute process described above but is more usually of a chronic nature and situated in the anterior part of the organ. It is generally due to infection through some superficial lesion which has quickly healed It presents as a tense swelling, fluctuation in which may be masked by the amount of inflammatory thickening which surrounds it. An incision both settles the diagnosis and cures the condition.

Sublingual Abscess When acute, this is due to infection of the submucous tissue, as by puncture with a fish-bone, or starts in a follicle of the sublingual or in a submucous gland. A puffy swelling forms beneath the tongue, which *may lead to an extension downwards into the submental* region. If the condition worsens, a large brawny swelling develops and constitutes *Ludwig's angina.* The tongue becomes swollen and turgid from pressure upon the veins, while œdematous laryngitis may also be induced. Considerable constitutional disturbance generally accompanies this process. Antibiotics should be given. A median incision through the mucous membrane, and the insertion and opening of a pair of dressing forceps, is the safest and best method of treatment, the cavity being subsequently washed out and drained. When the cellulitis is below the mandible external incision is required

Chronic Superficial Glossitis. This is a common and important disease which may be associated with a similar condition of the mucous membrane lining the interior of the cheeks and lips. It occurs most commonly in men between the ages of forty and sixty is very intractable and in about a quarter of the cases is certainly pre malignant It is sometimes found in clean mouths but is usually associated with either dental sepsis, excessive smoking or drinking, tertiary syphilis or chronic dyspepsia

For purposes of description it is useful to divide the disease into the following five stages, although it must be clearly understood that they are artificial, and several of them may be present in different parts of the same tongue (*a*) The papillæ become enlarged and swollen leading to the appear ance of red hyperæmic patches, which cannot be recognized for certain unless the tongue is thoroughly dried with gauze. This should be firmly pressed down so as to absorb all the moisture (*b*) Overgrowth of epithelium



FIG. 30 1 LEUKOPLAKIA OF THE TONGUE.

follows and as it increases in thickness it becomes opaque and horny so that the red patches are replaced by white ones, leading to the appearance which has been designated *leukoplakia*. Sometimes the papillæ become much enlarged, and stand out definitely and separately from the organ or the whole surface may be covered with dense white patches. To this condition the term *ichthyosis* has been applied. (*c*) Later the excess epithelium is shed, leaving red smooth patches in which the papillæ are atrophied, or have entirely disappeared. If this occurs over the greater part of the organ, the *glazed red tongue* so characteristic of tertiary syphilis is produced. If however this process only occurs in smaller areas intermixed with portions covered with white epithelium a patchy appearance of the tongue results, wrongly termed *psoriasis linguæ* (*d*) At varying periods of the disease, sometimes earlier sometimes later the organ becomes ulcerated, cracked, or fissured in a somewhat characteristic manner A median fissure is usually seen running down the dorsum, and from this, furrows extend transversely dividing the surface into rectangular compartments. These fissures are not always due to the cicatrization of cracks, as when opened out healthy papillæ are seen at the base, and no sign of superficial scarring. They are, then, evidently the result of the contraction of deep sclerosed tissue in the substance of the organ. Superficial ulceration often occurs. (*e*) Still later *carcinoma* may develop.

The typical *smoker's patch* is a red irritable area on the front of the tongue, from which papillæ are often absent. It is often covered with a yellowish white crust. Sometimes the epithelium is heaped up here into a well marked leucoplakic spot.

Chronic superficial glossitis may also coexist with chronic pharyngitis in those patients who exhibit fissures at the angles of the mouth with secondary anæmia.

Small leukoplakic patches are often painless but sometimes there is much discomfort the tongue being so sensitive that the patient cannot drink hot fluids or take condiments or stimulants without pain. The speech becomes thick and indistinct. The affection may settle down after a time, and remain quiescent so long as the patient conforms to the restrictions as to diet which are essential.

Treatment All sources of irritation are excluded from the mouth as a first precaution. Smoking or chewing tobacco should be prohibited and alcohol is forbidden. Condiments, such as mustard, spices and curry are excluded from the diet. *Attention to the teeth is of first importance.* The mouth is washed out frequently with an alkaline lotion *e g* sodium bicarbonate (20 grains to 1 ounce, 1 3 g. to 30 ml) or borax (10 grains to 1 ounce, 0·6 g. to 30 ml.), especially after meals. For the rest, the management is one of close inspection at frequent intervals. The use of silver nitrate, chromic acid or perchloride of mercury is to be deprecated. If a leukoplakic patch develops any "depth" or a fissure shows induration it is much better that it should be widely excised, preferably with diathermy and the material submitted to histological examination.

The administration of large doses of vitamin B has been advised, as also has androgen therapy But there is little evidence to show that these are beneficial. However the daily administration of 100 000 international units of vitamin A is occasionally helpful and this is in keeping with the experimental observation that vitamin A is necessary for the proper maturation of epithelial cells

Chronic Parenchymatous Glossitis. This is usually a manifestation of tertiary syphilis being a diffuse gummatous infiltration It may coexist with carcinoma of the tongue.

A form of chronic subepithelial glossitis due to a streptococcus is also described as occurring in women and children. With the general improvement in dental hygiene it is now seldom seen

Ulceration of the Tongue. Some of the causes of ulceration have already been mentioned, *e.g* the ulceration accompanying various forms of glossitis, dental ulcer (Vincent's angina), infections and trauma. Syphilitic ulceration is described later

Dyspeptic Ulcers These occur usually on the dorsum of the tongue near the tip or on the lateral border They are minute pimples, the pain of which is out of proportion to their size. There is very little evidence that they are in fact associated with dyspepsia.

Tuberculous Ulcers These are not common, and are nearly always secondary to pulmonary or laryngeal phthisis. They start as a submucous abscess, which bursts and leaves a small painful sore usually situated at the sides or on the dorsum near the tip Secondary abscesses form around and coalesce with the original ulcer Treatment apart from that directed to the primary disease, is chiefly needed on account of the pa and dis-

comfort, and consists in complete excision or in cocainizing and scraping the sores touching the base with pure carbolic acid and dressing with iodoform. Insufflation of orthocaine and benzocaine may also be made before meals as a palliative measure Occasionally tuberculous disease appears in the form of a painful fissure which on being opened up reveals a mass of pulpy granulations and occasionally caseating nodules, lying in a cavity of some size the margins of the fissure are sometimes the seat of over hanging papillary growths (*tuberculous papilloma*) Excision is essential in these cases *Lupus* also attacks the tongue but is very uncommon, and almost invariably secondary to a similar affection of the skin of the face

Syphilitic Disease of the Tongue This occurs in a variety of forms A *primary* sore presents a characteristic indolent and inactive surface usually near the tip with subjacent infiltration and much chronic enlarge ment of the submental lymph nodes which, however do not generally suppurate In the *secondary* stage mucous tubercles fissures and ulcers form usually on the sides or near the tip Occasionally a broad wart-like condyloma develops on the dorsum which may be associated with longitudinal fissures this is the classical Hutchinson's wart. In the *tertiary* period chronic superficial glossitis occurs as also diffuse infiltration or gummata.

Gumma of the tongue is now uncommon occurring usually in patients under forty years of age, as a late tertiary phenomenon It starts as a localized



FIG. 30 2. GUMMA OF THE RIGHT SIDE OF THE TONGUE.
(*From a Wax Model in R.C.S Museum.*)

submucous or intramuscular infiltration near the median line and generally towards the middle or posterior part The swelling is at first hard and firm but later on becomes soft and fluctuating, and in time ulcerates. The ulcer thus produced is oval or round in shape, and deeply excavated, the base being constituted by a slough. There is but little induration either of the base or edges, and neither the floor of the mouth nor the base of the tongue is involved, so that the organ can be freely protruded, while deglutition and articulation are scarcely affected. The patient complains of little pain, and the neighbouring lymph nodes are seldom affected. Progress is slow but the effect of antisyphilitic treatment is dramatic, the gumma being absorbed, or the ulcer if present, healing readily but leaving a localized area of sclerosis or a deep cicatrix, from which malignant disease may subsequently originate In some cases a diffuse infiltration of the organ occurs, leading to a generalized sclerosis rather than to a localized gumma (chronic parenchymatous glossitis).

Dermoid Cysts. These form within or under the tongue, occupying the

middle line, projecting either into the floor of the mouth or beneath the chin, according to whether the cyst is above or below the mylohyoid muscle. They can be distinguished from those due to non-obliteration of the upper end of the thyroglossal duct since the latter contain glairy fluid. The contents of dermoids, however are of the usual sebaceous type. Such tumours should rarely be dealt with from the mouth, as they extend deeply and need to be carefully dissected out. An incision should be made beneath the chin, and the whole cyst removed unopened.

Ranula. This is a cystic swelling of the floor of the mouth, white or pale blue in colour situated (unlike a dermoid) to one side of the midline and containing a glairy fluid which is not saliva. There is much controversy as to its origin but it is not due to the blockage of the submandibular salivary duct and probably not to one of the small sublingual ducts either The more likely explanation is that it is a form of dermoid cyst or of the cervical sinus. Sometimes there are projections of the cyst amongst the muscles of the floor of the mouth (dissecting ranula).

Treatment Ideally complete excision should be undertaken but too often the very thin mucous wall bursts during manipulation and its limits are then lost. As much as possible should be excised and the rest of the cavity either packed and allowed to granulate or coagulated with diathermy

Hairy Tongue. Black, hairy tongue is an unusual condition in which the filiform papillæ of the dorsum are long and stained black either by bacterial action or chemical decomposition of food. Although symptomless, the condition is usually a worry to the patient. Temporary relief can be obtained by "shaving" the tongue. Sucking penicillin lozenges predisposes to it.

Lingual Thyroid. This occurs as a painless, round, elastic tumour bulging from the dorsum of the tongue in the region of the foramen cæcum. It is dark red or purple in colour has large vessels on its surface and may be cystic. Rapid increase in size causing difficulty in swallowing and speech, may result from hæmorrhage into the tumour Serious bleeding may arise from its surface It is composed of thyroid tissue in an aberrant position and may represent all the thyroid gland there is. Removal should therefore not be done unless hæmorrhage makes this essential. Often a lingual thyroid can be made to shrink in size if the patient is given thyroid by mouth.

Neoplasms of the Buccal Cavity

Both innocent and malignant growths occur in the mouth. But the dividing line is by no means a sharp one and the former may frequently undergo malignant change as has already been mentioned in respect to leukoplakia. Moreover there is a common mucous membrane lining the buccal cavity and therefore it is not at all uncommon to find multiple growths occurring at the same time or arising at a later date owing no doubt to the multicentric origin of cancer This may also account for some so-called recurrences of disease after the successful treatment of a growth in other words, it is a new primary

Neoplasms occurring in the tongue floor of mouth, palate and buccal mucosa have much in common and are therefore best considered together Those affecting the lips, alveolar processes and tonsils are described in other chapters.

Innocent Neoplasms. These are comparatively uncommon. *Lymph-*

angioma and *hæmangioma* of the tongue have already been considered *Lipoma* and *fibroma* are described *Sialomata* arising from salivary tissue rests in the buccal mucosa of the cheek and floor of the mouth are not very uncommon and often proceed to malignant change with ulceration and metastases. They tend to be more proliferative than invasive An *adenoma* is occasionally seen on the palate (Fig 30 11). A lingual thyroid is frequently mistaken for a tumour owing to its appearance as a lobulated fleshy mass on the posterior third of the tongue

Papilloma This is the commonest innocent tumour of the tongue It is seen in children and also in older subjects in association with syphilis



FIG. 30 3 PAPILLOMATA OF TONGUE, SECONDARY TO CHRONIC SUPERFICIAL GLOSSITIS



FIG. 30 4. PAPILLOMA OF THE TONGUE IN A BOY AGED 8

or chronic superficial glossitis. In the former there is little danger of malig nancy but in the latter this is extremely probable and even a biopsy may be misleading. The proper treatment is wide excision, postoperative irradiation being given if histological examination suggests that there are malignant changes present.

Malignant Neoplasms. Almost all tumours of this sort arising in the tongue or elsewhere in the mouth are squamous-celled carcinomata. Rarely in children, a *rhabdo-myosarcoma* is encountered. *Lympho-epithelioma* has been described occurring in the posterior third of the tongue and faucial region but some pathologists prefer to regard such growths as anaplastic carcinomata.

The relative malignancy of buccal neoplasms, and consequently the prognosis, depends upon the accessibility of the tumour for purposes of treatment and the natural disposition to metastasize. In this respect, the lateral border of the anterior two-thirds of the tongue, the alveolar mucosa and the hard palate are best the floor of mouth and buccal mucosa next best while the posterior third of the tongue, vallecula and soft palate carry the worst prognosis

Carcinoma of the Tongue

This occurs ten times more commonly in men than in women. The age incidence is high, being usually above sixty It may arise as a result of the irritation caused by excessive smoking, especially when neglected, rough, and carious teeth are present. The Wassermann reaction is positive in about 15 per cent. of cases



FIG. 30 5. CARCINOMA OF THE TONGUE.
In this case the patient presented with a large growth on the left side and leucoplakic patches on the right side.

Pathology Its mode of onset varies somewhat according to the situation (*a*) It arises most commonly as an ulcer on the lateral margin, towards the junction of the middle and posterior thirds (*b*) it may start in a crack, fissure, or cicatrix on the dorsum as a result of chronic superficial glossitis (*c*) it may commence as a wart like growth, the base of which becomes infiltrated, the tumour invading the muscular substance, and spreading to the root of the tongue (*d*) it may originate as a submucous infiltration, starting as an ingrowth from the mucous membrane, without much external manifestation of its presence (scirrhous type) (*e*) it may first be noticed as

may be involved. Ultimately the disease spreads to the deep nodes lying along the main vessels, a node lying over the bifurcation of the common carotid artery being early enlarged. These nodes, if not removed, soon attain considerable dimensions, and become stony hard and fixed to surrounding structures, especially the carotid sheath These secondary growths not uncommonly become cystic in character from the degeneration of the masses of epithelium formed within them after a time they approach the surface and burst, leaving ragged malignant ulcers in the neck. The lower jaw itself is often invaded in the later stages of the disease The occurrence of the typical cachexia is determined not only by the pain and consequent sleeplessness, but also by the inability to take sufficient nourishment, the absorption of products of putrefaction swallowed with the saliva, the excessive salivation, the occasional hæmorrhages, and the extent of the secondary growths. The patient rarely lives unless treated for more than twelve months after the disease has been first noticed Death is due to exhaustion hæmorrhage, or septic pneumonia.



FIG 30 7 CARCINOMA INVOLVING THE ANTERIOR TWO-THIRDS OF THE TONGUE.



FIG. 30 8 RADIUM NEEDLE VOLUME IMPLANT IN THE SAME PATIENT

There is usually little doubt about the diagnosis. A biopsy and a Wassermann test should be done in all cases but neither a negative result to the first test nor a positive to the second should exclude carcinoma, for syphilis and carcinoma often coexist.

Clinical Staging It is customary to divide carcinoma of the buccal cavity into stages this assists both the planning of treatment and the assessment of results. In stage 1 the growth is strictly limited to the tissue of origin in stage 2 neighbouring structures are involved. There are no palpable nodes in either stage in stage 3 mobile, unilateral nodes are present in stage 4 the nodes are either fixed, bilateral or distant metastases are present.

Treatment *Irradiation* This is unquestionably the method of choice. It is true that an early non-infiltrating lesion can be widely excised and a cure effected in this manner but such a lesion can also be irradiated with equal success and less mutilation

For neoplasms of the anterior two-thirds of the tongue or buccal mucosa interstitial radium needling is advised and the distribution of the needles follows the plan laid down by Paterson and Parker It is not necessary to go into details but the principle observed is that the whole volume of the tumour together with an area of surrounding tissue should be uniformly irradiated to a dosage of 6 000 to 7 000 *r* This may be achieved by the use of needles containing 1 2 or 3 mg. of radium screened by 0 5 mm of platinum and disposed either as single plane, two-plane or volume implants

For neoplasms of the infralingual surface of the tongue and floor of mouth (which are clinically similar) posterior third of tongue, vallecula and faucial pillars, telecurie therapy is the method of choice though high-voltage X-ray therapy may be used The advantage of this method is that the



FIG. 30 9 THE TELERADIUM UNIT IN USE. (*Middlesex Hospital.*)

immediate areas of lymphatic drainage are also irradiated. A radium "bomb" may contain 1 to 10 g. of radium. Radioactive cobalt or cæsium are also in use in similar machines in quantities equivalent to as much as 1 kg. of radium.

For small neoplasms of the hard palate and alveolar mucosa, contact X ray therapy or a radium or tantalum-wire applicator may be used. With external as opposed to interstitial irradiation it is sometimes difficult to give an adequate dose and such cases may be followed by the insertion of radon seeds or radioactive gold wire (gold grains) to bring the dosage up to an appropriate level.

The object of irradiation therapy is to destroy all malignant tissue in one application. If this is not achieved it is found that any residual or recurrent growth is more resistant to the action of the rays. By contrast, the normal tissues are more sensitive so that subsequent treatment tends to produce radionecrosis without eradicating the growth. Residual or recurrent disease should therefore be treated by surgery and the best method is dia thermic coagulation.

Treatment by Excision Surgical excision is advisable when the mandible or upper jaw are involved, when the whole of the anterior portion of the tongue is infiltrated or if adequate radiotherapy is not available. The excision must include not only the tumour, but also a wide area of tissue around it, so as to get well beyond the zone of infiltration not only the lymphatic nodes, which are obviously enlarged, but also the whole lymphatic area, extending practically from the base of the skull to the episternal notch. It is obviously desirable to undertake such extensive operative proceedings in two stages, if possible, dealing first with the tumour in the mouth, and subsequently with the nodes The fact that recurrence is rarely noted in the portion of the organ that intervenes between the two operative areas indicates that such a practice though not ideal, is justifiable

If the tip only is involved, it can be removed by a V-shaped incision, *made after steadying the tongue with a deep suture.* The small ranine artery will spurt on each side, but is easily secured, and the gap is then closed by sutures. When the disease involves one side of the tongue and is not very extensive, and does not spread deeply into the base, it will suffice to remove the anterior half or two-thirds of the affected side as a first stage without touching the nodes. If both sides of the tongue are involved, but the disease has not extended deeply into the base, it is not difficult to effect removal. The mouth is gagged open, and two silk slings are inserted, one through the anterior portion and the other just in front of the epiglottis. The mucous membrane of the floor of the mouth is incised on either side, and the muscles attached to the genial tubercles divided. By this means the *tongue is considerably loosened and can be drawn well up out of the mouth,* so as to enable the section to be made across it with scissors at the desired level. The main vessels can generally be seen and secured before division, and the amount of bleeding is not excessive It is often possible to draw forward the stump of the tongue and secure the mucous membrane anteriorly so as to diminish the size of the raw area in the mouth.

The removal of a part of the tongue is not such a mutilation physiologically as one might expect at first. Deglutition is interfered with *for a time,* but the power is soon regained and even articulation may be in great measure restored.

Treatment of Regional Nodes In cases of stages 1 and 2, *i.e.* when no nodes are palpable, it is now no longer customary to perform a so-called prophylactic block dissection. But a most careful follow-up of all treated cases is essential and if nodes become palpable this operation should be carried out and if necessary on both sides of the neck. Block dissection should be undertaken only when the nodes are clinically operable and when the primary has been controlled. When nodes are fixed, radiation should be employed as a palliative measure.

Crile's radical operation extends from the mastoid process and submental area to the suprasternal notch and outer third of the clavicle. It removes a block of tissue *including the internal jugular vein* and the sternomastoid. If the disease has involved both sides of the tongue, both sides of the neck must be cleared and even when the disease has only apparently affected one side of the tongue the nodes on both sides of the neck may be involved. The incision extends along the anterior border of the sternomastoid throughout its whole length, and a second *incision* meets it, *reaching from* the chin to just below the great cornu of the hyoid bone. The flaps thus

marked out are dissected up and turned forwards the platysma being included in them An alternative incision is illustrated in Fig 30 10 Raising the four flaps formed by the two Y incisions gives a most excellent exposure The deep fascia is divided in the mid line and over the posterior triangle and is turned inwards. The sternomastoid muscle is then detached from the clavicle and the mastoid process In the lowest part of the wound the internal jugular vein is doubly ligated and divided together with the omohyoid muscle and external jugular vein On the left side care must be taken not to injure the thoracic duct otherwise a troublesome chylous fistula will result The dissection then proceeds up the neck, taking with it the carotid sheath and all lymph nodes with ligation of the middle

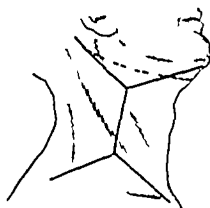


FIG. 30 10. BLOCK DISSECTION OF THE NECK.
The incisions for Crile s operation are shown. The dotted line is the incision used for a suprahyoid dissection.

thyroid common facial, lingual and occipital veins. The submental and submaxillary triangles are also cleared with excision of the submandibular salivary gland and ligation of the facial vessels Finally the internal jugular vein is divided at the top and the mass of tissue excised The carotid arteries and hypoglossal nerve are left bare but the accessory nerve is sacrificed with the sterno-mastoid The wound is closed carefully with drainage and a firm dressing is applied The opposite side of the neck is similarly dissected two to three weeks after the first.

THE PALATE

A number of conditions affecting the palate have already been described. It should be emphasized that the hard palate and the soft palate are developmentally different and often the diseases affecting them behave differently The soft palate forms a part of the inlet of the oropharynx together with the anterior faucial pillars.

Cleft Palate. This condition is described with cleft lip in the chapter devoted to plastic surgery (Chapter 40)

Ulceration of the Palate. This results from a number of causes (*a*) *simple* as an accompaniment of general stomatitis (*b*) *syphilitic* which may involve either the hard or soft palate if superficial, it is usually a late secondary phenomenon if deep, it involves the bones, and often leads to necrosis and

is then due to tertiary disease (*c*) *tuberculous*, which may take one of two forms. Caries of the hard palate may give rise to a subperiosteal cold abscess or the palate may be the seat of *lupus* which has spread from the nose or face (*d*) *malignant* in which case the carcinoma may arise from the mucosa of either the hard or soft palate. *In the latter case there is often extension* from the fauces or tonsil.

Perforation of the Palate. Though this is occasionally caused by trauma or lupus, in almost all cases it is due to tertiary syphilis. The ethmo-vomerine septum is often involved in the destructive process, giving rise to a most offensive discharge from the nose. If the soft palate is alone affected, the velum may become fixed by cicatricial adhesions to the back of the pharynx, and pharyngeal stenosis, or considerable loss of substance of the velum, results. Perforations are best remedied by the use of plate obturators.

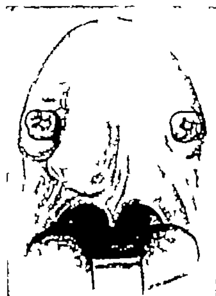


FIG. 30 11 ADENOMA OF THE PALATE.

Tumours of the Palate. These have been considered with neoplasms of the buccal cavity The hard palate may be involved in an *epulis* extending from the alveolar process and *adenoma* and *sialoma* are fairly common in this situation. Malignant disease of the hard palate may be primary or it may be an extension from a growth in the maxillary antrum. This should be borne in mind when planning treatment. Any tumour of the upper jaw may displace or involve the palate.

Carcinoma of the soft palate is, as stated, a more serious condition than that of the hard palate chiefly because its lymphatic drainage is bilateral and more prolific. Metastases are therefore earlier in development.

Elongation of the Uvula. This may result from chronic pharyngitis. The elongation causes much irritation of the back of the tongue and fauces, resulting in a troublesome throat cough and even vomiting. Under exceptional circumstances it should be removed. After well cocainizing the part it is grasped by a pair of hook forceps, which raise not only the mucous membrane, but also the muscular structures beneath, and a sufficient amount is then removed by snipping it across near the base with a pair of blunt-ended scissors, leaving about a third of an inch of the organ behind.

THE SALIVARY GLANDS

Acute Parotitis. This occurs in a number of different forms.

Epidemic Parotitis (Mumps) This is a highly infectious acute specific disease usually seen in children. The period of incubation is about three weeks, and the attack itself consists in a slight febrile disturbance associated with swelling of one or both parotid glands one gland is attacked first, becoming enlarged and tender whilst the other side is similarly affected in a day or two Mastication becomes difficult owing to the tension of the parts The swelling usually persists for about a week and then gradually subsides it extends below and in front of the ear the lobe of which is characteristically displaced forwards The upper deep cervical and submandibular nodes are sometimes enlarged. Suppuration never occurs but in adults metastatic inflammation of the testis breast, ovary or pancreas is not uncommon This complication is generally unilateral, and thus although atrophy of the testis commonly follows orchitis, sterility is not produced. There is no specific treatment.

Simple Parotitis This may result from exposure to cold or from injury the presence of a stone in the duct or irritation of the orifice of Stenson's duct by an ill-fitting denture. There is also a troublesome form of recurrent

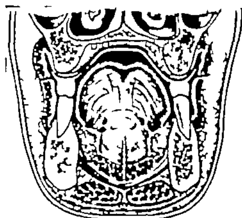


FIG. 30 12. DIAGRAM SHOWING THE RELATION OF AN UPPER DENTURE TO THE ORIFICES OF STENSEN'S DUCTS.

parotitis seen in children which is presumably caused by infection travelling along the duct The acute phase can be relieved by penicillin or chlortetracycline but there is no effective prevention to recurrence.

Allergic Parotitis In children and occasionally adults with an allergic diathesis there is sometimes recurrent swelling of the parotid glands. A small plug of mucus heavily infiltrated with eosinophils may be found obstructing Stenson's duct and the white cell count shows an eosinophilia.

Post-operative Parotitis This was a fairly common complication of abdominal operations before it became known that the infection was a buccal one and reached the gland by the parotid duct. To-day it is very rare, since oral sepsis should be treated before any abdominal operation is contemplated, and patients are not allowed to become dehydrated. In spite of attention to fluid balance and giving antibiotics however the condition sometimes progresses to suppuration and requires incision.

Suppurative Parotitis This is a more serious condition It may extend from the mouth along Stenson s duct, or supervene in the course of pyæmia, or as a sequela of some of the exanthemata, e.g scarlet or typhoid fevers. The gland becomes enlarged, with congestion and œdema of the overlying skin and owing to the tension of the fascia, exceedingly painful. Treatment is by antibiotics initially but if there is no response incision should not be delayed, because the gland may undergo necrosis and form large sloughs. Incisions must be adequate and often need to be multiple. The anatomy of the facial nerve must be borne in mind.

Chronic Parotitis. This may occur in glass-blowers and wind-instrument players following acute emphysema of the gland. It may also result from oral sepsis and in a condition in which the terminal radicals of the duct are dilated known as *sialodectasia* The treatment is unsatisfactory and it may be necessary to destroy the function of the gland, as described later

Inflammation of Submandibular Gland. The same types of inflammation (including mumps) may affect the submandibular glands as the parotid



Fig. 30 13 Calculi Removed from Submandibular Salivary Ducts

gland If the inflammation extends beyond the capsule of the gland a diffuse cellulitis termed Ludwig s angina may result.

Salivary Calculus. Calculi are the chief cause of obstruction to the flow of saliva. Composed of calcium phosphate and carbonate, they form more frequently in the submandibular ducts than in the parotid ducts. This is because the former glands secrete saliva containing more mucus than the latter Submandibular stones are usually single, fusiform and of fair size. Parotid calculi tend to be multiple and small Most calculi are opaque to X rays.



Fig. 30 14 Submandibular Gland with a Calculus Embedded in it



Fig 30 15 Calculus in the Duct of the Submandibular Gland.

Symptoms There is painful enlargement of the gland during and after meals, gradually disappearing as the saliva finds its way past the block in old-standing cases the gland becomes chronically enlarged and its interstitial tissue increases in bulk while a certain amount of periadenitis also follows. When a calculus is present there is usually a considerable discharge of offensive mucopus into the mouth Where the obstruction is complete a cyst may form and if this is opened or finds its way to the exterior and bursts, a salivary fistula results Sialography may assist in the localization of a calculus or show chronic distension of the ducts This investigation is mainly applicable to the parotid gland, lipiodol being injected through a blunt cannula into the duct while the skiagram is taken



FIG. 30 16. NORMAL SIALOGRAM OF THE PAROTID GLAND

Treatment Calculi usually become impacted in the infralingual portion of Wharton's duct and often close to its orifice. They should be removed from within the mouth and preferably under general anæsthesia. If placed deeply in the substance of the submaxillary gland, total removal of the gland should be performed

Parotid calculi, being small and multiple, are usually situated in the gland and not in the main duct and therefore have to be removed through an external incision.

Ranula. A ranula is a cystic swelling in the floor of the mouth, at one time considered to be a retention cyst of salivary tissue. But this is not so and the condition is therefore described on p 730

Salivary Fistulæ. Fistulæ of the submandibular gland are uncommon and usually heal of their own accord the rare cases which do not are treated by excision of the gland.

Fistulæ of the parotid gland or duct are most frequently caused by injury or by suppuration around a calculus. In operations for removal of nodes from the upper part of the neck, the lower part of the parotid may be wounded, and a small fistula will result which generally heals almost at once, unless the wound becomes infected, when a permanent fistula may

follow When the duct is involved, the nearer the lesion is to the gland, the more difficult it is to cure. Spontaneous healing is very rare, and the portion of the duct in front of the fistula frequently becomes stenosed and sometimes obliterated. Should the fistula be situated in front of the masseter operation will often cure. In recent cases, such as a stab injury the wound should be opened up and the two ends of the duct isolated. A piece of stout silkworm gut is passed from the mouth through the orifice of Stensen's duct and out on to the face it is then passed into the proximal portion of the duct and thus acts as a dowel. The wall of the duct is sutured over the piece of silkworm gut, and the skin wound closed This method is only of use when the wound is recent.

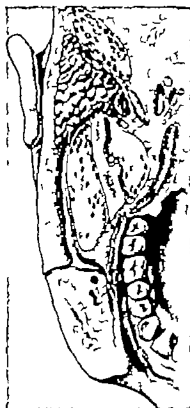


FIG. 30 17 METHOD OF FORMING A NEW OPENING INTO THE MOUTH BY MEANS OF A SUTURE THROUGH THE BUCCAL MUCOUS MEMBRANE.

In old-standing cases of premasseteric fistula the following procedure will sometimes suffice A straight needle threaded with silk is passed through the fistula into the mouth the needle is then unthreaded, and the piece of silk outside the mouth is threaded on to it. The needle is then inserted through the fistula into the mouth a second time The two ends of the silk are then tied in a knot. The included piece of tissue which is strangulated by the suture dies and sloughs, and by this means an opening is made into the mouth. As the parotid secretion has now a free vent into the mouth the fistula heals.

Fistulæ of the portion of the duct overlying the masseter muscle are difficult to cure and the best way is to abolish the secretion of the gland. One method is by radiotherapy a dose of about 1 500 r being given. An-

other is avulsion of the auriculotemporal nerve which is located through a vertical preauricular incision lying with the superficial temporal artery

Salivary Gland Tumours. These are of considerable interest and may be simple or malignant. However it is now recognized that the simple sialoma is not so benign as was supposed and not only is local recurrence common but frank malignant change often follows.

Sialoma of the Parotid. This is the so-called *mixed parotid tumour* which is characterized by the presence of spaces containing material resembling cartilage. There has been and still is, some controversy as to the nature of these tumours. But they are now generally agreed to be solely of epithelial origin. This was the original theory until some pathologists thought that cartilage and other mesodermal elements pointed to a " mixed " origin.

These cells which give the tumour its characteristic appearance are in reality epithelial cells set in a mucinous matrix. The tumours are derived



FIG. 30 18 SIALOMA OF THE PAROTID

most frequently from the ducts of the glands, but in a few cases from the secreting cells. The *mucinous material, which is such a prominent feature* of most of these tumours, is a true secretion of mucin from the tumour cells, and is only an exaggeration of a normal function of the gland cells.

Adenolymphoma This is a distinct pathological type of growth, also known as a papillary cystadenoma. It is not malignant.

Clinical Features Sialomata are equally common to either sex, and know no age incidence they may occur in children or old people. They are usually situated in the superficial portion of the gland substance, are coarsely nodular and vary in consistence in different parts. They are very slow growing and the history is often measured in years rather than months. They may also less commonly occur in other situations such as the roof of the mouth, the gums, or the cheek. *The facial nerve in its course through* the gland is deeply placed and hence is not pressed on by these tumours unless they undergo malignant change. They have a pseudo-capsule formed of compressed gland tissue which permits of ready enucleation, though this is now regarded as not being the best treatment.

Treatment Because of the liability to recur excision is a better treatment

than enucleation though this is a more difficult operation and damage to the facial nerve must be avoided If the tumour is a large one it may be necessary to remove the whole of the superficial portion of the gland. A generous incision should be made, placed vertically in the preauricular region

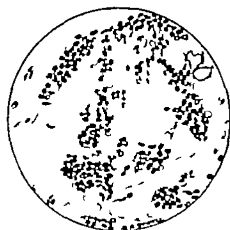


Fig 30 19 Low power View of Section of Sialoma, showing Area resembling Cartilage.



Fig. 30 20. Sialoma of the Parotid Gland (Operation Specimen × ½)

and extending forwards beneath the angle of the jaw The facial nerve should be identified at its exit from the stylomastoid foramen and dissected forwards with its branches It is advisable to combine operation with irradiation and this can be given as X rays or teleradium before excision or radium needles may be implanted at the end of the operation.



Fig. 30 21 Malignant Sialoma of the Parotid.

The drooping of the eyelid and general asymmetry of the face are indicative of the facial nerve paralysis caused by the growth.



Fig. 30 22. Sialoma of the Submandibular Gland.

Malignant Tumours of the Parotid. These occur in the form of carcinoma or sarcoma, and are sometimes secondary to a simple tumour the change of type being marked by increased rapidity of growth and greater pain The mass becomes more fixed, and signs of pressure upon the vessels and nerves develop the facial nerve is very likely to be implicated leading to paralysis of the face. Moreover the skin becomes hyperæmic and often adherent to the tumour, and finally ulceration and even fungation may obtain Secondary deposits occur in the regional lymph nodes or in the viscera, and the patient soon passes into a state of malignant cachexia

Treatment All malignant parotid tumours should be irradiated before attempting excision. If there is a facial nerve palsy excision is in a sense easier because for this condition a total parotidectomy is necessary and this inevitably means some damage to the nerve however carefully it is dissected from its origin at the stylomastoid foramen. In exposing the deep part of the gland it will often be found that the two main branches of the nerve are closely adherent to the neck connecting the superficial and deep portions If lymph nodes are enlarged the incision may be carried down the neck so that a block dissection, including removal of the sternomastoid muscle, may be done. It may also be necessary to divide the ascending ramus of the mandible to obtain adequate exposure.

Tumours of the Submandibular Gland. Similar types occur here as in the parotid gland though very much less commonly A swelling of this salivary gland is often mistaken for an enlarged lymph node though the fact that it is also palpable from within the mouth helps to determine the true nature of the lump The gland is of course more easily removed and sialomata are less likely to recur On the other hand, carcinomata appear to be highly malignant.

Mikulicz's Disease. This term is applied to a chronic, progressive enlargement of the salivary and lacrimal glands, associated with lymphocytic infiltration and fibrosis. Young adults are those affected and apart from the deformity which the condition produces the main symptoms are conjunctivitis caused by the xerophthalmia and dry mouth. The disease is considered to be the result of an auto-immune reaction and is thus comparable to Hashimoto s disease of the thyroid gland.

Chapter 31

THE NOSE, PARANASAL SINUSES AND NASOPHARYNX

Methods of Examination

In order to investigate fully the diseases of the nose, it is essential that the organ be efficiently examined, and to do this seven methods are employed

(1) *External Examination.* The nose is first examined externally for signs of displacement or deformity of the bony framework, due to previous injury or inflammatory changes. It must also be noted whether redness or swelling is present and whether the skin is affected by ulcerative or neoplastic diseases.

(2) *Anterior Rhinoscopy* This consists in inspection of the nasal fossæ through the anterior nares. A good light is required, either reflected from a frontal mirror or derived from an electric headlamp together with some form of nasal speculum. Thudichum s speculum is satisfactory It consists of two unfenestrated blades, connected by a U-shaped spring. The ring and index fingers are placed one on each limb so as to regulate the amount of tension and to prevent painful overstretching. The blades are inserted into the nostril, the nasal vibrissæ being thus held aside. By this means one is enabled to examine the nasal fossæ, including the middle and inferior turbinate. Expansion of the latter limits the view of other structures If greatly swollen, it feels soft and even fluctuating, but collapses on the application of a 2½ per cent. solution of cocaine, allowing the free convex border of the middle turbinal to come into view as also the cleft or olfactory fissure between it and the septum. The septum can also be examined, frequently showing deviations from the middle line, and thickenings or spurs of bone or cartilage which run in an antero-posterior or oblique direction. Any excess of secretion is observed, with a note as to its nature, whether mucoid or purulent.

The introduction of a sterilized probe under the guidance of the eye is of value in examining the nose, particularly in determining the size and attachments of nasal polypi.

(3) *Posterior Rhinoscopy* Examination of the posterior nares is carried out by a mirror placed behind the uvula and soft palate. It is by no means easy to accomplish, and requires some dexterity and practice. The tongue should be depressed and a small mirror the glass surface of which is previously warmed to prevent condensation of moisture, is then passed behind the uvula, without touching it or the posterior wall of the pharynx, and by shifting its angle and position a view should be obtained of the structures in the nasopharynx and posterior choanæ. The posterior nares (or choanæ) are seen, separated by the posterior free margin of the septum, and within each cavity the rounded ends of the turbinates. Of the inferior turbinal only a portion can be seen owing to the prominence of the velum palati, but

the middle turbinate bone can be examined in greater detail at its posterior end. Lateral to the choanæ are seen the openings of the Eustachian tubes and above and between them Luschka's tonsil a collection of lymphoid tissue in the roof of the nasopharynx which forms adenoids when enlarged

The nasopharyngoscope is a miniature telescope designed for the direct examination of the nasopharynx Practice enables its employment to be of value in certain cases.

(4) *Palpation of the Nasopharynx* Palpation without anæsthesia should be avoided. If such an examination were essential the surgeon should stand behind the patient, with the head held firmly the left cheek being pushed in between the molar teeth with the left forefinger to prevent biting the index finger of the right hand is passed behind the uvula and velum, and the nares can be explored, and the existence of adenoids or other growths determined

(5) *Transillumination.* This is carried out in a dark room and can be of great value. To illuminate the antra, a bright lamp is placed in the patient's mouth and the lips closed upon it The hand shields the light from the mouth and the two antra can be compared To assess the frontal sinuses the light is pressed firmly against the skin at the inner canthus, but this information is of little use.

(6) *Skiagraphy* Radiographic examination of the paranasal sinuses is often an essential investigation.

(7) *Bacteriological Examination.* The discharge from the nose may give information of value especially when a recurrant nasal infection is present. The nasal fossæ are usually sterile and it may be necessary therefore to take swabs from the nasopharynx. Various forms of bacteria are found and a swab allows their culture and sensitivity to antibiotics to be determined. A vaccine will sometimes protect the patient for a considerable time The meningococcus may effect a lodgment in the nasal fossæ without the patient experiencing any ill-effect, as also the *Corynebacterium diphtheriæ* and carriers of these organisms may spread infection.

THE NOSE AND NASAL SEPTUM

Alteration in the Shape of the Nose. This may be congenital or due to a fracture or displacement of the nasal bones, or may follow defective growth of the ethmovomerine septum, due to disease of congenital syphilitic origin early in life, or may result from tertiary syphilis or lupus. A common cause in childhood is hæmatoma or abscess of the septum due to injury leading to necrosis of the septal cartilage and subsequent falling in of the bridge. Early incision of a hæmatoma or abscess is desirable, in an attempt to avoid obstruction or deformity of the nose. In adults, a falling in at the tip of the nose may be caused by too extensive removal of the front portion of the septal cartilage during the operation of submucous resection for septal deviations.

Expansion of the Nose This is always the outcome of some long-continued intranasal pressure, especially from new growths. It follows the development of mucous polypi, when they are very large and of long standing. The bridge is flattened and bulged out on either side, giving the face an appearance justifying the name "frog-nose" (Fig. 31 1) which has been applied to it nasopharyngeal fibroma can produce a somewhat similar result.

Partial or Total Destruction of the Nose This may result from disease or injury or it may be the necessary end result of eradication of a growth. Lupus, tertiary syphilis, epithelioma and rodent ulcer among diseases, and gunshot wounds and motoring accidents amongst traumata are the most



FIG. 31 1 EXPANSION OF THE BRIDGE OF THE NOSE (FROG-NOSE) RESULTING FROM THE PRESENCE OF MUCOUS POLYPI.



FIG. 31 2. RODENT ULCER ON THE NOSE.

common causes The operation of rhinoplasty is described in the chapter on Plastic Surgery (Chapter 40)

Skin Affections. The skin of the nose may be the site of acne or sebaceous cysts In the most exaggerated stage the sebaceous glands become overgrown



FIG. 31 3 RHINOPHYMA.

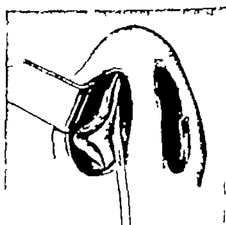


FIG. 31 4 SUBMUCOUS RESECTION OF THE SEPTUM.

and form large protuberant nodular masses projecting from the end of the nose covered with red greasy skin in which the dilated orifices of the glands are very evident and with dilated capillaries coursing freely over them. This condition is generally known as *rhinophyma* or hammer nose. It may be checked in its incipient stages by the judicious use of X-rays when

fully developed operative treatment is required The best procedure is to shave away the exuberant masses with a razor or scalpel. The islands of epithelium left at the extremities of the sebaceous pits rapidly spread over the raw surface Great care must be taken to avoid opening into the nasal cavity and a finger in the nostril is probably the best precautionary measure to use as a guide during the shaving process. Hæmorrhage is free, but is readily checked by iced saline compresses and pressure dressings Diathermy coagulation is useful for persistently bleeding points. Only occasionally is it necessary to skin-graft the raw surface left by the shaving process.

Affections of the Nasal Septum. By the term *spur* is meant a localized cartilaginous or bony ridge or thickening of the septum which runs in a more or less oblique direction along the upper border of the vomer A *deviation* is a bending of the septum from the middle line, causing inequality of the nasal fossæ the cartilaginous septum is mainly involved and the condition is sometimes of traumatic origin. The two conditions are usually combined, and may be associated with a high-arched palate Deviation of the septum, when severe, gives rise to nasal obstruction and may predispose to chronic rhinitis, or to obstruction of the ostia of the nasal sinuses, with resultant headache or inflammation of catarrhal or suppurative type. Nasal asymmetry may be present in cases of deviated septum due to injury To correct deviations, with or without spurs or ridges, *submucous resection* of the septum is performed, preferably under local analgesia or occasionally under general anæsthesia, and the results should be excellent. The mucoperichondrium and mucoperiosteum are stripped up first on the convex side, then on the opposite surface and the whole thickness of the cartilage and bone removed the two layers are then replaced in contact, and by their union constitute a median septum (Fig. 31 4)

Foreign Bodies. These are sometimes impacted in the nasal passages of children. Unilateral purulent discharge, sometimes bloodstained, from a child's nose should suggest the likelihood of such an occurrence peas, beads, or buttons are the substances usually introduced. A certain amount of unilateral obstruction to nasal respiration is caused thereby followed by a catarrhal or suppurative rhinitis in old-standing cases a rhinolith or nasal calculus may be formed by the deposit of inspissated mucus upon the outer surface of a foreign body Removal is best effected in adults by thoroughly cocainizing the affected side so as to reduce the congestion and swelling of the mucous membrane, and then seizing the foreign body by suitable forceps, a hook, or a snare. For children a general anæsthetic is required. Removal should never be attempted without the assistance of satisfactory illumination and a nasal speculum, nor in a struggling child. Necessarily all instruments used for this purpose should be thoroughly sterilized. The old-fashioned plan of attempting removal by syringing is most unsatisfactory and indeed dangerous it should be discarded.

Epistaxis. Bleeding from the nose arises from a variety of causes, including injury directed either to the mucous membranes or the bones, or from the presence of ulceration or tumours. Some of these local causes are very evident, if they are carefully looked for with a speculum and frontal mirror The site of bleeding is almost invariably an area on the anterior part of the septum, where an anastomosis is formed between the septal branch of the sphenopalatine artery and branches from the anterior ethmoidal

and coronary vessels. One of the commonest lesions is a small abrasion or ulcer of the septum, usually over a deviated area and due to detachment by the finger of a scab or dried crust of mucus which causes irritation within the nostril each time the nose is "picked" in this way bleeding recurs. *Another frequent source of epistaxis is the rupture of a varicose vein in the* mucous membrane of the septum varix occurs not unusually in plethoric individuals and sneezing or blowing the nose violently may lead to an attack (Fig. 31 5). Foreign bodies may cause hæmorrhage as also ulceration of an angioma or of telangiectasis on the septum. It frequently occurs in young people about puberty in consequence of local disturbance in the vascular arrangement of the parts again cerebral congestion may induce *it, owing to the communication by means of emissary veins between the* interior of the skull and the venous plexuses in the nose excessive changes

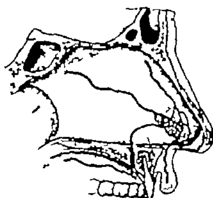


FIG. 31 5. BLOOD-SUPPLY OF THE NASAL SEPTUM, SHOWING THE ANASTOMOSES IN AN AREA CLOSE BEHIND THE NASAL VESTIBULE, THE "BLEEDING AREA."

in the atmospheric pressure, as in mountaineering, can lead to epistaxis, while in abnormal states of the blood it may be associated with hæmorrhage elsewhere as in hæmophilia, purpura, and scurvy Epistaxis is also a symptom of some types of neoplasm of the nose or paranasal sinuses. It is sometimes seen in nephritis, and may be one of the first symptoms to call attention to the existence of this disease It may follow cardiac or pulmonary disease with raised blood pressure or with cerebral congestion and may be a prominent symptom in dysentery One or both nostrils may be the seat of the bleeding, and it may be so excessive as to threaten life.

Treatment It must not be forgotten that, in the majority of cases, there is some *local cause of epistaxis which can be found and treated directly* The bleeding is generally unilateral and in nine out of ten cases the source is within easy reach of the anterior nares, being placed on the septum just behind the vestibule of the nose by *grasping the nostrils firmly* so that the ala is pressed against the bleeding-point for ten minutes, the hæmorrhage is controlled, and an opportunity given for clotting. At the same time the patient should sit up with a cold compress applied to the root of the nose or to the nape of the neck *If on examination the bleeding-point is detected*, whether it be a varicose vein or an ulcerated surface the hæmorrhage can almost at once be stayed by sealing the spot with a probe tipped with fused chromic acid the galvanocautery can be used but less conveniently Failing these measures the nostrils may need to be plugged. It may be

decided to pack the anterior nares with ribbon gauze soaked in 1 in 1 000 adrenaline, or a sterilized rubber finger-stall may be introduced and filled with gauze If the pack is to remain in position for several hours the gauze should be soaked with soft paraffin and iodoform. If this does not suffice, the posterior nares must also be plugged this procedure is required especially when there is bleeding from the sphenopalatine artery or its posterior branches. For this purpose a rubber catheter is employed in order to pass a thread round the base of the palate, and out of both nose and mouth To the lower end of this thread or catheter a pack of sterilized gauze soaked in iodoform, about 3 or 4 cm by 2 cm in size, is attached and this, guided by the finger round the soft palate, is drawn tightly forwards into the posterior nares. It is a good plan to have two threads coming forwards out of the nose and these are tied firmly around a pad of lint placed over the side of the nostril thereby occluding the anterior nares and completely blocking the nasal cavity back and front. The loose end of the thread emerging from the mouth is fixed to the cheek by a strip of adhesive plaster The plug is retained for twelve or even twenty-four hours and then removed being replaced if necessary

Severe cases of epistaxis may require blood transfusion. Bleeding high up in the nasal fossa may require ligature of the ethmoidal arteries.

Inflammatory Diseases

Acute Rhinitis. This condition is extremely common, constituting what is popularly known as a " cold in the head." It is not only due to exposure to cold, but is also caused by irritating gases or dust, and is one of the prodromal symptoms of influenza, scarlet fever measles and whooping cough. Not only is the nasal mucosa involved but the inflammation often extends to the sinuses, particularly the maxillary causing brow-ache and face-ache, while if it spreads to the mucous lining of the Eustachian tube, temporary deafness ensues. Anosmia and partial loss of taste may be present. Apart from the usual remedies directed to increasing the action of the bowels, kidneys and skin, considerable relief can be obtained by steam inhalations containing friars balsam, menthol, and eucalyptus oil every three or four hours. In infants dyspnoea results owing to obstruction of the nasal passages, and this may be so marked as to interfere for a time with breast feeding the infant attempts to breathe through the nose, since mouth-breathing is an acquired habit.

Acute rhinitis is frequently associated with acute suppuration in one or more accessory sinuses, and then treatment must be directed mainly to the sinusitis. The discharge is abundant and causes much obstruction to nasal respiration because of marked swelling of the mucous membrane. The nasal passages must be cleared with steam inhalations, but nasal douches must not be used, because of the danger of infecting the middle ear A solution of ephedrine may give relief if used as drops in saline containing ½ per cent., or in a spray of saline solution to which ½ per cent. has been added. Antibiotics are required in very severe cases.

Chronic Rhinitis

This condition occurs in several distinct types, a brief description of which follows.

Simple Chronic Rhinitis. This occurs often in those working in a dusty

atmosphere, and is usually associated with inequality of the two nasal fossæ due to deviation of the nasal septum It may appear after the subsidence of an acute attack. The mucous membrane is seen to be redder than usual, and is slightly thickened thus giving rise to nasal obstruction. Search must be made for a cause in any of the nasal sinuses or in the nasopharynx, where adenoids may be present. Locally sprays of chlorbutol and glycerin in normal saline with the addition of silver protein (½ per cent.) or of ephedrine (½ per cent.) in some cases are useful the most important point, however is to discover and remove the cause.

Hypertrophic Rhinitis. This common form of rhinitis is characterized by engorgement of the erectile tissue covering the inferior or middle turbinate bones, causing obstruction to nasal respiration and an excess of mucoid secretion. The entire nasal mucosa, septal as well as turbinal, may be involved. It is more common in male patients with prominent noses, where the passages are narrow it may run in families and occurs in certain races It occurs with marked septal deviations on the concave side, closing up a roomy nostril, and may be lighted up by some slight local irritation such as a sudden change of temperature It is frequently associated with and aggravated by infection of one or more of the paranasal air sinuses, careful examination and treatment of which must be carried out. The inferior turbinal is chiefly involved it is swollen, red, and rounded, the mucous covering being thickened. The local application of a 2½ per cent. solution of cocaine causes its complete, though temporary collapse in a few moments If allowed to persist, hyperplasia of the mucous membrane follows, and in the most marked types a projecting papillomatous-like mass appears at the posterior extremity this condition is often termed *moriform enlargement* from its likeness to a mulberry The mucous covering of the middle turbinal may participate in the same process, but in this region the thickening of the mucosa is pale and of a more œdematous type. A certain amount of pharyngitis or laryngotracheitis may also be present.

In the early stage all that is required is the use of steam inhalations of menthol and benzoin, or a spray containing sodium bicarbonate and chlorbutol each of ½ per cent. with glycerin (10 per cent.) in normal saline, together with ephedrine (½ per cent.) In severe cases a galvanocautery at a red heat may be run along the length of the inferior turbinal bone.

In certain cases œdematous hyperplasia of parts of the nasal mucous membrane takes place and leads to the formation of polypi, with great obstruction to respiration. Any infection of the sinuses must be dealt with.

Straightening of the nasal septum, or removal of part of the middle turbinate bone is sometimes necessary The posterior end of the inferior turbinal may be snared but the main part of this structure must not be removed.

Nasal Allergy This may take one of three forms (*a*) *Hay-fever* or seasonal allergy (*b*) *Perennial Nasal Allergy* sometimes known as paroxysmal rhinorrhœa or allergic rhinitis and (*c*) *Chronic Nasal Œdema* characterized by œdematous swelling of the mucosa associated in some advanced cases with the formation of nasal polypi.

Nasal Polypi. These are œdematous formations, sometimes resulting from long-standing rhinitis of hyperplastic type, but more often the result of allergic swelling of the mucosa they are soft gelatinous masses, which on microscopic examination much resemble myxomatous tissue covered

by ciliated columnar epithelium They are sometimes associated with a secondary chronic osteitis of the underlying bone. They may be associated with suppuration of the adjacent sinuses especially the ethmoidal but the pus production may be secondary and not causative Polypi are usually situated above or below the middle turbinate, arising from the lower border of the middle turbinal or from the ethmoidal cells. They start occasionally in the maxillary frontal or sphenoidal sinuses they do not involve the septum or inferior turbinate Polypi are generally multiple (Fig. 31 6), a large one projecting downwards and forwards towards the anterior nares, and covering or hiding a series of smaller ones which readily spring into prominence when that in front is removed They are usually attached by a small pedicle, and when developing in the nasal fossa are pyriform and laterally compressed. When of large size, they may cause expansion of the bridge of the nose (Fig. 31 1), and even reach the nostrils, when the epithelium



FIG. 31 6. MUCOUS POLYPI OF THE NOSE (DIAGRAMMATIC).

Translucent, smooth, pale nasal polypi are seen hanging in the nasal fossa. One originates in the frontal sinus and lies under cover of the middle turbinate bone, in close proximity to one arising from an anterior ethmoidal cell. Posteriorly one has escaped from the sphenoid sinus, and another from a posterior ethmoidal cell. There is also commencement of polypus formation on the lower border of the middle turbinate.

covering the anterior portion becames squamous, and the mass firmer in texture and papillomatous in appearance. An *antrochoanal polyp* is one, usually single and of large size when recognized, which springs from inside the maxillary antrum, passes through the antral opening, and travels backwards into the posterior choana and nasopharynx it is generally hollow being formed by cystic eversion of the mucosa.

Symptoms The chief symptom of nasal polypi is obstruction to the passage of air along one or both sides of the nose. This is of gradual onset, and invariably worse in wet weather on account of the hygroscopic property of mucoid tissue. There is often a thin, watery discharge from the nose. The patient is unable to blow the nose, and his articulation becomes nasal in quality Ill-defined headache is common, and is due to obstruction of the nasal openings of the frontal sinuses. On rhinoscopic examination one finds a greyish, semi-translucent, glistening mass occupying the nasal fossæ. The pedunculated nature of a polypus can easily be demonstrated by passing a probe around it.

Diagnosis This should present no difficulty to one who knows how to

employ the nasal speculum. Abscess, a spur or a deviation of the septum, though causing unilateral obstruction can be recognized by careful examination. Œdematous masses of granulation tissue, associated with tuberculous or syphilitic disease of the bones, are recognized by their colour by the involvement of the septum as well as the turbinals, by the absence of superficial epithelium, and by not being distinctly pedunculated carious bone can often be felt by a probe through the granulation tissue. *Polypi* differ from hypertrophy of the mucous membrane over the inferior turbinate they do not spring from this region while the latter condition is sessile, red and shrinks considerably on the application of cocaine. They are distinguished from malignant new growths by their pale colour smooth surface and avascularity

Treatment This usually consists in their removal by the snare or forceps. Anti-allergic measures and particularly the giving of calcium gluconate and dilute nitrohydrochloric acid may be of help zinc ionization is required in some recurrent cases.

The snare is especially indicated if there is a single polypus hanging down the nasopharynx, or if the polypi are few in number The patient is seated in a chair or on an operating table with a rest to support the head, and the surgeon sits or stands in front. The nasal cavities are anæsthetized with a paste of cocaine (25 per cent.) with adrenaline. This is prescribed as follows Chlorbutol gr 5 cocaine hydrochloride gr 120 desiccated adrenal gland (5 in 1) gr 24 liquid paraffin 220 m. soft white paraffin to 1 oz. A solution of equal parts of cocaine (10 per cent.) and adrenaline may also be used. The situation of the pedicle is ascertained, if possible, by inspection and by the use of a probe. The snare is then introduced the loop passed round the base of the pedicle, and gradually tightened. The polyp is then torn away and often brings with it the area of carious bone which lies beneath it. The same process is repeated to the smaller masses until the nose is clear The cavity does not require to be tightly plugged afterwards for hæmorrhage, unless the latter is very severe if packing be inserted it must not be tight, or too highly placed for fear that meningitis may arise from infection through the cribriform plate.

If recurrence has occurred after the removal by the snare the nostril must not only be effectively cleared, but the underlying bone must be removed for the cure of the ethmoiditis. Radical ethmoidectomy is often desirable in the first place Antrostomy also may be required.

Rhinitis Sicca. This condition is characterized by loss of vascularity and deficiency of secretion from the glands of the nasal mucous membrane. It is found in those who work in hot and dry rooms and is treated by the application of oily solutions or of a stimulating paint, such as that of Mandl (iodine and potassium iodide) A spray of sodium bicarbonate ½ per cent., chlorbutol ½ per cent., glycerin 10 per cent. in normal saline is useful for its mild hydroscopic effect. Small doses of potassium iodide (gr 3–5 0·2–0·3g.) are of use for increasing secretion

Atrophic Rhinitis. This generally starts in childhood and usually in an underfed child, who may be debilitated by tuberculosis or is the subject of congenital syphilis. It is a condition due to deficiency of blood-supply and to alterations in the supply of and viscosity in the quality of the nasal mucus. It may follow in the train of hypertrophic rhinitis, because of contraction in the chronically inflamed submucous tissues. When severe it is characterized

by an exceedingly evil smell, due to saprophytic decomposition of crusts when this occurs the condition is known as *o ena*. Some cases are caused by infection of the maxillary sinuses, a thorough examination of which must be made It must be carefully distinguished from the offensive condition due to tuberculous and syphilitic disease the impaction of foreign bodies or the ulceration of malignant growths.

The erectile tissue is collapsed and the ciliated epithelium is lost in places, or may be replaced by stratified epithelium What secretion there is dries on the surface of the mucous membrane and gives to it a glazed appearance The nasal fossæ are roomy because of shrinking of the mucosa and atrophy of the nasal turbinate bodies. Usually both sides are involved, but occasionally one nasal fossa only is affected if the septum is markedly deflected It is on the roomy side that the changes are first seen, while on the narrow side there may be hypertrophy or hyperplasia.

The pharyngeal wall is often dry and crusted, and the larynx and trachea may present the same appearances.

Treatment The first essential is to keep the nose clean and free from putrefying masses of dried secretion. A spray of chlorbutol and glycerin may suffice, but sometimes cleansing must be accomplished by irrigating the cavity once or twice daily with a warm solution of sodium chloride, sodium bicarbonate and phenol. Every portion of scab ought to be removed daily and the surface lubricated with some such application as a spray of oil of pine (1 per cent.) in liquid paraffin. The local application of crude cod liver oil or of œstrogen in almond oil is efficacious.

Various means of narrowing the nose have been devised, with success in some cases. Operative measures, however are seldom required, except for the treatment of an infected maxillary sinus.

Diphtheritic Rhinitis. This is now extremely rare on account of the decline in the incidence of this disease due to immunization. But it may occur as a local and non-systemic condition, rendering the subject a carrier

Syphilitic Rhinitis. This disease is generally tertiary in type, and consists in a diffuse affection of the nasal bones, septum and turbinals, with resultant suppuration and either caries or necrosis. The condition is usually a very offensive one the accessory sinuses are not specially liable to involvement. Treatment is of the usual antisyphilitic type, with injection of penicillin and arsenic or bismuth preparations, and occasionally the use of iodides and mercury Locally the nose must be kept clean by irrigation and removal of diseased bone. If the septum is seriously affected, the bridge of the nose will become depressed. In cases of congenital type the disease may start in infancy causing the condition known as snuffles considerable deformity results from destruction of the nasal bones.

Tuberculosis. Lupus vulgaris is a chronic condition starting typically at the junction of skin and mucous membrane in the vestibule Jelly-like nodules appear which ulcerate and coalesce, leading to destruction of the cartilaginous nasal septum with the formation of a perforation. The disease spreads both along the cartilages and also outwards to the skin of the face, with signs of healing in places and contraction loss of tissue and contraction produce deformity and falling-in of the tip of the nose. Secondary deposits appear in the palate, fauces or larynx. A more active form of tuberculosis sometimes occurs with destruction of parts of the bony septum, but never with perforation of the hard palate as in syphilis.

Treatment is directed to the removal of the focus by excision or diathermy General treatment is given to improve the health preferably in a sanatorium ultra violet radiation gives good results in some cases. A specific remedy for this disease is calciferol with the alternative of streptomycin combined with PAS

THE PARANASAL SINUSES

Disease of the accessory sinuses of the nose is a frequent accompaniment of either the acute or chronic nasal affections just passed under review or it may arise from more localized lesions, *e g* antral trouble from affections

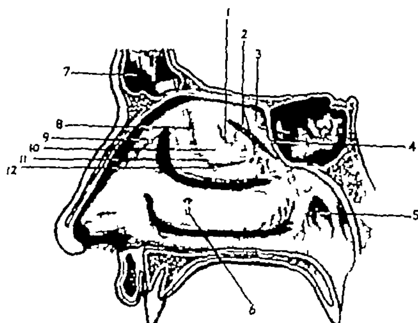


FIG. 31 7 OUTER WALL OF THE NASAL FOSSA, INDICATING THE POSITION OF THE ORIFICES OF THE PARANASAL SINUSES.

1 Middle turbinate bone.
2. Opening of posterior ethmoid cells.
3 Superior meatus.
4 Sphenoid sinus with bristle in ostium.
5 Eustachian tube.
6. Probe in nasolacrimal duct under cover of inferior turbinate.
7 Frontal sinus.
8. Opening of frontal sinus.
9 Agger nasi.
10. Bulla ethmoidalis.
11 Lip of hiatus semilunaris.
12. Ostium of maxillary sinus.

(Adapted from Cunningham, "Textbook of Anatomy")

of the teeth, or frontal sinus infection from external injury Perhaps the most common cause is a sharp influenzal attack which may lead to an involvement of the nasal fossæ and all the sinuses (*pan-sinusitis*) this is amenable to treatment in the early stages but if neglected may become chronic and give rise to serious trouble There is then persistent discharge of purulent material from the nose which when arising from a maxillary antrum infected by a septic tooth root, is often offensive to this may be added special features according to the particular sinuses which are affected. A particularly virulent form of acute sinusitis, of fulminating type, is caused by bathing and by jumping feet first into a freshwater pool.

It must be remembered that the outlet of some of the sinuses (Fig. 31 7) is badly placed for drainage purposes, especially that of the maxillary

antrum the opening of which is nearer the roof than the floor drainage being maintained by ciliary action Even in the case of the frontal sinus the outlet, which is well situated for drainage, is a long, narrow passage easily blocked by œdematous swelling of the mucous lining. When once suppuration has commenced in the sinuses it may spread from one to another owing to the close proximity of the various orifices. The maxillary sinus is most frequently infected, with the ethmoidal cells next in order Infection of the frontal sinus is more rare and is almost invariably secondary to infection of the maxillary sinus.

In the *acute* cases which follow influenza or cold the antrum is most frequently involved The infecting organisms are usually streptococci or pneumococci For mild cases of sinusitis, antibiotics are not desirable when the condition is very acute and associated with high fever penicillin should be given in full doses. In the early acute stages, irrigation of the nasal fossæ should never be ordered, but medication by means of steam inhalations should be employed the antrum may later need washing out, after cocainizing the inferior meatus and puncturing the wall with trocar and cannula, on every third day if necessary Any more extensive operation is extremely dangerous in the acute stage, and should be avoided for at least ten days from the commencement of the disease, except in rare cases.

In *chronic* cases there is discharge from one or both sides of the nose, and the patient complains of feeling stuffed up breathing will be mainly oral On examining the interior of the nose, even after cleansing it, the cavity is found to be obstructed and sometimes blocked up by swollen turbinals or by polypoid masses, which project from the middle meatus. Pus may be seen in this region, and comes from frontal sinus, maxillary antrum, or ethmoid cells. In an established case the antrum should be punctured and thoroughly washed out if afterwards more pus appears on hanging down the head it must come from the frontal sinus or ethmoidal cells. Pus lying above the middle turbinate comes from the posterior ethmoidal cells or the sphenoidal sinus. Transillumination and radiography are important aids to diagnosis.

The Maxillary Sinus

This sinus, or the antrum of Highmore, is a cavity lying within the maxilla it is roughly pyramidal in form and triangular on section. The bony walls vary much in thickness, but the orbital, nasal, and facial aspects are thin Below the roots of the upper molar teeth and sometimes the bicuspids are separated from it merely by a thin plate of bone above, the infra orbital nerve and vessels are imbedded in the superior wall. It is lined by an extension of the mucous membrane of the nasal cavity the ostium is on the mesial wall, being badly placed for drainage purposes, nearly an inch from the floor so that any escape of secretion—if abundant and not removed by ciliary action—is by overflow This opening, moreover is under cover of the middle turbinal, not far from the lower end of the fronto-nasal duct and the exit of the anterior ethmoidal cells, so that when infection has attacked one cavity it is likely to spread to others.

Injury This is usually caused by blows or falls. There may be simple contusion, with escape of blood into the lumen this is best left *alone*, as aseptic reabsorption is to be expected

A simple fracture line may pass through the infra-orbital foramen with

unsightly depression, which calls for elevation of the depressed fragment the malar bone may in addition, be involved

Compound fractures are treated by purification and elevation In severe cases the maxilla needs to be held in place by traction from a rod attached to the forehead by plaster

Distension of the Antrum. This may arise from new growth or dental cyst formation and is manifested in any of four directions (*a*) inwards, causing obstruction to nasal respiration, and possibly epiphora, from compression of the nasolacrimal duct (*b*) upwards, leading to protrusion of the eyeball, or exophthalmos (*c*) downwards, resulting in depression of one side of the palate, and possibly irregularity in the line of teeth and (*d*) outwards, giving rise to a somewhat characteristic projection of the cheek beneath the malar eminence. Under these circumstances, a finger inserted into the mouth, between the cheek and the bone, will detect fulness and possibly a loss of resistance in the anterior wall of the antrum or the whole anterior wall may be absorbed and an elastic swelling take its place Infra-orbital neuralgia is a marked feature in such of these cases as are of rapid progress.

Hydrops Antri. This term is applied to a chronic distension of the antrum with a glairy mucoid fluid, somewhat similar in character to that contained in a ranula it is due to the formation of a dental cyst which has encroached on the antral cavity rarely it is due to the presence of a dentigerous cyst, and in certain cases to cyst formation in the mucosa. The treatment required is to open the cyst thoroughly through the canine fossa An opening is made into the inferior meatus of the nose to drain both antrum and cyst.

Empyema of the Antrum. This may complicate an abscess connected with the roots of the molar or premolar teeth it more commonly results from an acute inflammation of the nasal cavities due to infection by pneumococcus or streptococcus, and may be associated with inflammation in the other accessory nasal sinuses. It is occasionally lighted up by injury as in boxing, football, or fighting or the cavity may be infected by bathing in the sea, stagnant ponds, or swimming baths.

Symptoms These are often overlooked and the condition is often present for some time without being recognized.

In *chronic* forms all that is noticed may be intermittent discharge of pus from one side of the nose, associated with nasal obstruction a chronic cough and an irritable throat. The pus varies considerably in amount and character, being sometimes extremely offensive. On holding the head forwards, there may be an overflow of pus into the nostril, and sometimes when the patient reclines it flows back into the pharynx. *Cacosmic* (a bad smell perceived by the patient) is almost always diagnostic of dental-root infection of the antrum with mouth organisms. Should the opening into the nose become blocked, all the symptoms are aggravated, possibly with pain and swelling.

In acute cases all the above phenomena may be present, accompanied by severe tensive pain and some amount of febrile disturbance. Toothache in one or more teeth of the affected side is often due to neuritis of one or more branches of the superior dental nerve. Osteomyelitis of the bony walls may also be included in children, since the mucous membrane is closely adherent to the periosteum. This complication, however usually results from primary infection in a tooth socket.

Diagnosis The diagnosis of empyema is not always easy The discharge of pus from the nose is suggestive, particularly if following a cold in the head, or if associated with the presence of a dead or painful molar or bicuspid tooth If a flow of pus can be induced by change of position of



FIG. 31 8. EMPYEMA OF THE RIGHT ANTRUM.
A fluid level is seen.

the head, it is suggestive of suppuration within one of the accessory sinuses connected with the nose, probably of the antrum. If after the nose has been cleared and the head hung down, pus is seen welling up from under the middle turbinal, the diagnosis is almost certain. Transillumination of the antrum helps to confirm this opinion. A suitable electric lamp is placed within the mouth in a dark room, or the examination is made under a



FIG. 31 9 THE FRONTAL, ETHMOIDAL AND MAXILLARY SINUSES SHOWN DIAGRAMMATICALLY
The figure illustrates the good drainage of the frontal sinus as compared with that of the antrum of Highmore, in which the ostium is placed high up, thus favouring stagnation of secretions. A trocar and cannula are in position for lavage of the maxillary sinus the instrument pierces the naso-antral wall below the inferior turbinate bone.

photographer's cloth if the antra are normal, the cheeks, lips, and lower margins of the orbits become of a rosy red colour On pulling down the lower lid the sclerotic is seen illuminated in its lower part and the pupil shows up as a red area the light having passed through the antrum into the globe of the eye. If, however the cavities are occupied by pus, blood, a growth or polypi or if the mucous lining or bony walls are thickened, the parts remain dark. Transillumination is not accurately diagnostic in every individual, and hence the value of the test is diminished. The presence of illumination generally excludes intra-antral growths or abscess, but its absence, unless unilateral, is not of much significance. Differences of illumination on the two sides are, however of considerable diagnostic significance.

Radiographic examination is of considerable value the films being exposed through the occipitomental plane A fluid level may be visible if there is retained secretion in hyperplastic cases thickening of the lining membrane or polypus formation may be revealed.

Finally the antrum may be punctured with trocar and cannula through the inferior nasal meatus, and an absolute diagnosis obtained by washing it out.

Treatment This varies with the type of the disease. In very acute or fulminating cases injections of penicillin are required in mild cases this is not necessary or desirable. It must always be remembered that the orifice of the antrum into the middle meatus is an inch above the antral floor and hence the natural drainage is defective, being merely of an overflow type when the patient is erect if ciliary action is ineffective or has been paralysed.

In persistent acute cases the cavity should be washed out from the nose, the inner wall being punctured through the inferior meatus after efficient cocainization warm sterilized salt solution is employed. Lavage is not required during the first few days of an acute attack, when the pus is thin, but is indicated when the ostium becomes obstructed by coagulated secretion. This lavage may be required at first on alternate days, but afterwards less frequently and in the intervals the patient is guarded from cold. Steam inhalations of friars balsam, menthol, and eucalyptus oil every three or four hours are very helpful and comforting. For steam inhalations 1 pint of water at 180° F should be placed in a jug, and the solution added. A towel in the form of a cone is placed around the mouth of the jug the nose and mouth are held over the jug, the eyes remaining outside, away from the steam. The patient breathes through the nose, and closes one nostril at a time he should expire mainly through the mouth, continuing the inhalation for five to ten minutes. He must remain in an even temperature for half an hour after the inhalation. A simple prescription is menthol gr 3, compound tincture of benzoin 60 m. In addition, a spray containing ½ per cent. ephedrine may be required if obstruction is severe.

It is important to make certain that the point of the cannula is actually within the antral cavity before commencing lavage, as it is possible that it is still in the nasal cavity, or has crossed the antral cavity and may be (*a*) in the orbital cavity, or (*b*) under the cheek in the canine fossa, or (*c*) in the pterygoid region. The syringe should always be filled with lotion before commencing the lavage, as there is danger of air-embolism if this precaution be overlooked. The face must be watched when the syringe is first squeezed to detect any swelling due to malplacement of the needle.

In chronic cases, if puncture and lavage are ineffective, intranasal operation will usually suffice to be effective the anterior part of the inner (nasal) wall of the antrum under cover of the inferior turbinate must be removed to allow of dependent drainage and lavage of the antrum. In cases of long standing there may be marked degeneration of the lining mucosa or a large accumulation of polypoid tissue within the antrum. To remove it the surgeon must make an opening for inspection by incising the mucous membrane and periosteum over the canine fossa, after retracting the upper lip. He then makes an opening through the anterior bony wall (*Caldwell-Luc operation*) Effective removal of hyperplastic mucosa can then be performed under direct vision, but this buccal opening is closed at the end of the operation. The lining membrane should not be completely removed, except in very rare cases An opening into the nasal fossa is made through the inferior meatus, as in intranasal antrostomy

Drainage of the antrum through a tooth socket was formerly in vogue, but is now abandoned, because of the disadvantage of constant reinfection of the cavity from the mouth.

The Frontal Sinuses

These sinuses lie within the frontal bones and are lined with a mucous membrane continuous with that of the nose. They are seldom large before the age of puberty In adults they vary much in size and shape, and are often asymmetrical or single the prominence of the superciliary ridges is no guide to their extent. Information as to these points can be gained by radiography the rays being directed from behind and the plates placed in front. The presence of pus and of degeneration of the lining are determined in this way Transillumination is seldom useful.

Fractures. The anterior wall may be fractured from a direct blow depression of the fragments being produced but without cerebral complications. If the mucous membrane is torn, surgical emphysema of the scalp and face may follow and is naturally increased on blowing the nose In open fractures suppuration may occur leading to septic osteitis and necrosis of the frontal bone, and, if the posterior wall is involved, to escape of cerebrospinal fluid, or to an extradural or even a cerebral abscess When the anterior wall only has been destroyed, a localized collection of air may form under the skin, and remain as a permanent tumour known as a *pneumatocele capitis* it rises and falls with forced respirations.

Inflammation. Frontal sinusitis is caused by extension from the nose generally it follows or accompanies empyema of the maxillary sinus and seldom arises as a primary condition, except in rare cases of penetrating wounds or fracture, or from infection by water when bathing. It produces headache, localized to the region of the sinus, with pain or tenderness on pressure. Fever and a feeling of mental dullness are present. As mentioned above, no operation should be performed on the frontal sinus during the acute stage, except under necessity when an abscess has broken through its walls or occasionally when osteomyelitis is present. Reliance is generally placed, in severe cases, on the use of penicillin or other antibiotics. Lavage of the maxillary sinus is required in the majority of cases. This treatment is combined with steam inhalations and the encouragement of drainage from the frontonasal duct by the application to the region of the middle turbinal body of small pledgets of wool soaked in 10 per cent. Protargol

or in resistant cases, with the addition of a spray of ½ per cent. ephedrine, or occasionally 2½ per cent. cocaine solution.

In the treatment of chronic infection of the frontal sinus external operation is avoided if possible. Any infection of the maxillary sinus must be cured pathological enlargement of the middle turbinal is rectified by operation any polypi obstructing the frontonasal duct are removed, infected anterior ethmoidal cells are drained, and any marked deviation of the nasal septum is corrected If the condition is not cured or markedly ameliorated thereby external operation is performed. An incision is made just below the eyebrow medial to the supra-orbital nerve and curving round the inner margin of the orbit. Part of the floor of the frontal sinus is removed, but the anterior wall is left intact, except in rare cases of osteomyelitis.

A *free communication is made between the sinus* and the nose by removal of parts of the nasal, lacrimal, ethmoidal and superior maxillary bones. It is of great advantage and, in our opinion essential to apply a skin graft to the newly formed opening.

Mucocele Blockage of the frontonasal duct without infection of the cavity can lead to mucocele. The floor of the sinus at the inner angle of the orbit is expanded. External operation may be required.

Acute Osteomyelitis. This dangerous complication of acute frontal sinusitis is occasionally primary but is more often the result of surgical interference in acute cases.

In the spontaneous type the patient has a chance of recovery but the prognosis is very bad in post-operative cases. An afebrile and slowly progressive type may be seen, arising as a secondary complication of an operation on the ethmoidal cells or on the frontal sinus itself. Treatment with penicillin may be effective, but it is necessary in some cases, to carry out drastic operative treatment. An incision is made from ear to ear over *the vertex and a wide area of bone is removed sometimes* including the greater part of the frontal bone.

Intracranial Complications. Sinusitis may lead to extradural abscess, cavernous sinus thrombosis, localized or diffuse meningitis, or frontal lobe abscess. These rare complications are seldom spontaneous, but more often appear after operations. The infection arises from the frontal, ethmoidal, or sphenoidal sinuses, and passes in by *direct continuity after fracture or caries of bone or enters through venous channels.* Opening of the anterior fossa of the skull is carried out through the posterior wall of the frontal sinus if indicated, or through an independent osteoplastic flap. Meningitis of nasal sinus origin used to be almost invariably fatal, but is now controlled in most cases, by antibiotics.

The Ethmoid and Sphenoid Sinuses

Ethmoidal Cells. These *lie along the inner* wall of the orbit and should the orbital ethmoidal plate be perforated or necrosed, as a result of acute or chronic ethmoiditis, one or more cells may burst and infect the orbital cavity leading to orbital cellulitis, which is usually of nasal origin *Hyper*plastic ethmoidal disease leads to excessive polypoid formation and caries of bone takes place beneath the diseased mucous membrane *from* which the polypi are derived.

Fractures The usual cause of fractures are falls or blows on the nose and may be associated with tearing of the dura mater and the escape of

cerebrospinal fluid from the nose this accident may necessitate intra cranial operation through an osteoplastic flap, with closure of the cleft by a graft of muscle or fascia

The nose must not be douched or syringed while cerebrospinal rhinor rhœa is present for fear of meningitis.

Sphenoid Sinus. This lies beneath the sella turcica and drainage thereof in diseased conditions, is partly of the overflow type (Fig. 31 7) the discharge escapes downwards into the nasopharynx, and often leads to crust formation around the posterior nares Suppuration therein may cause deep-seated pain in the back of the orbit and nose, and over the occiput thrombosis of the cavernous sinus, retrobulbar neuritis, involvement of orbital nerves or even basal meningitis are possible complications.

Treatment of ethmoidal and sphenoidal sinusitis should be carried out by a specialist, as operative measures, often of a difficult and serious character may have to be undertaken. The essential element is drainage of the affected cavities, together with removal of the polypi and diseased bone which hinder the exit of the discharge In acute cases it is desirable to treat the patient merely by medicated steam inhalations, with a spray of weak ephedrine if necessary and possibly by lavage of the maxillary sinuses, but further and more effective treatment is usually required in chronic cases. In many patients the lining membranes of all the sinuses will be thickened and transformed into polypoid masses. The operative procedures mentioned are likely to be required, in addition, for the associated disease of the antrum. For disease of the ethmoid cells, it may be necessary after removal of the middle turbinate, to break through by means of Grünwald's forceps, and to remove the entire inner ethmoid wall, as well as the partitions between the various cells and all polypi some of the ethmoidal cells can be reached through the antrum, if the sublabial approach is used. For disease of the sphenoidal sinus part of the anterior wall must be removed by a special punch forceps down to the floor In mild cases of sphenoidal infection catheterization and lavage with saline solution may effect a cure. In severe cases, where all the sinuses are infected, it is preferable to work through an external incision in a combined fronto-ethmoid operation.

THE NASOPHARYNX

Adenoids. The nasopharynx is the seat of a collection of lymphoid tissue, similar to that met with in the tonsil, situated on the roof and known as the pharyngeal or Luschka s tonsil. Adenoids consist in hypertrophy of this tissue, exactly analogous to the chronic hypertrophic form of tonsillitis, with which, indeed, it is often associated. They occur in the form of broad, cushion-like masses in the vault. The formations are soft and vascular bleeding very readily The surface is plicated, and in the recesses or folds between the different portions of the mass bacteria lodge and give rise to various inflammatory troubles locally and occasionally in neighbouring lymphatic nodes. Not uncommonly isolated masses similar in structure to the above are to be seen on the posterior wall of the pharynx, and a certain amount of chronic rhinitis and laryngitis may be associated. The condition is rarely seen in adults and is most frequently found in children in whom a certain amount of lymphatic hyperplasia in this region is normal. If untreated, adenoids usually disappear before the age of twenty but occasionally harm has been done to the individual meanwhile.

Symptoms These are mainly due to obstruction to nasal respiration. The mouth is generally held half open, to allow the child to breathe through it thereby exposing the upper central incisors (Fig. 31 11) from a similar cause he or she snores during sleep and usually wakes with the mouth and tongue dry The nostrils are drawn in and the nose is thin and pinched, the whole facies being characteristic such children often look sleepy and half silly and may indeed be backward in their studies Not uncommonly there is a certain amount of semi-purulent discharge from the nose, or it may be hawked up from the pharynx, perhaps mixed with blood. Deafness is caused if the tympanic membranes are indrawn because of obstruction



FIG. 31 10 A CHILD WITH NEGLECTED ADENOIDS.

It will be seen that the chest is shallow and retracted, and the spine kyphotic. The arms are small, but the legs are well developed.



FIG. 31 11 ADENOID FACIES.

This illustration shows well the sleepy look, the pinched nostrils, the open mouth, and projecting upper central incisors, so characteristic of this condition.

of the Eustachian tube. Catarrhal otitis media may result from extension of the catarrhal condition to the mucous lining of the Eustachian tubes, and deafness may be induced thereby The presence of adenoids increases the chances of acute inflammation of the ear during attacks of acute rhinitis or nasopharyngitis and also interferes with recovery Both taste and smell are sometimes impaired as a result of hypertrophic rhinitis. The ethmoid and maxillary sinuses may become infected. The palate is high and arched, possibly owing to the altered intranasal pressure, and as the patient grows up the incisor teeth may project forwards giving a curious rabbit like expression to the face. The cervical nodes become infected from the tonsils they are enlarged and may be the seat of tuberculous disease. In bad cases which have been allowed to persist throughout adolescence the thorax becomes flattened the ribs are drawn in, and the spine is kyphotic.

Examination. Posterior rhinoscopy is essential, for by means of this the adenoids can be seen. Although available as a method of diagnosis,

palpation of the posterior nares is a process to be avoided in conscious children When carried out under anaesthesia it will be found that on passing the finger behind the velum, the nasopharynx is occupied by a soft mass of tissue which readily bleeds and more or less obstructs the openings of the posterior nares A lateral soft tissue skiagram is often helpful.

Circumstantial evidence is derived from the symptoms, from the presence of enlarged and unhealthy tonsils and from retraction of the tympanic membranes a diagnosis of adenoids should thereby be made without the necessity or desirability of the unpleasant post nasal palpation

Treatment Removal of the adenoids by operation is necessary if marked symptoms and signs are present. In mild cases improvement may be obtained by reduction of carbohydrates and increase of fats in the diet, by giving vitamin-containing cod liver or halibut oil and by the use of nasal drops of silver proteinate 5 per cent. In young adults arsenic in small

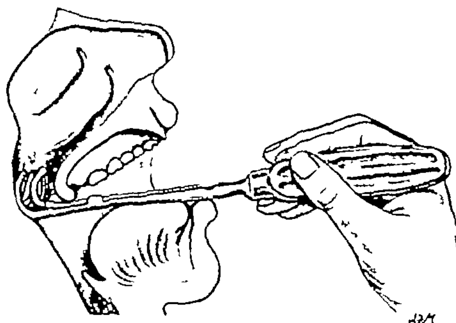


FIG. 31 12. REMOVAL OF ADENOIDS.

The adenoid mass is shown as partially removed from its attachment and bulging into the cage of the curette, which opens to receive it.

doses (arsenical solution 2 m., 2 or 3 times a day) may be of value after operation. Nasal douches must never be used for fear of setting up infection in the sinuses or ears The only way of dealing with the established condition is by surgical removal whatever the age of the child Infection of the maxillary sinuses is sometimes associated with the presence of adenoids and requires investigation and treatment by lavage, usually before the operation for removal of adenoids is carried out

Operation The child, lying flat on the back, or with a pillow under the shoulders, is anaesthetized with ethyl chloride, either alone or preferably followed by ether Premedication with Nembutal given by mouth is strongly recommended. If enlarged tonsils coexist, these should be dealt with in the first place (see Chapter 32) Gottstein s curette, or some modification

of it, is then introduced behind the soft palate, the head being flexed. The curette is pressed upwards so that its free convex edge impinges on the upper part of the posterior border of the nasal septum. It is then swept backwards and downwards over the pharyngeal wall so as to shave away the chief portion of the projecting mass of adenoids (Fig. 31 12). Possibly the application of a second curette may be required to deal with outlying portions any remaining tags are removed by the use of Luc s or any other suitable forceps. La Force s adenotome is a most useful instrument, and is prefered by many to a curette By its use the whole mass of adenoids can be removed cleanly with no possibility of damaging the pharyngeal aponeurosis or constrictor muscle. There is considerable bleeding, but this quickly stops of itself or after the application of silver proteinate (10 per cent.) or thrombin on a strip of muslin plugging of the nasopharynx is very rarely required. The blood is removed by a suction pump, but, if one is not available, the child should be turned over and held face downwards immediately after the operation, so as to allow the blood to run out of the mouth and nose, while the face and forehead are sponged with ice-cold water to check the hæmorrhage. Many surgeons prefer to perform the operation with the child lying on his side. The patient is kept indoors for a few days, and only fluid food allowed. The most likely complication is acute otitis media, indicated by earache and rise of temperature. No local after-treatment is required as a rule. Nose breathing exercises should subsequently be instituted and in many children are as important as the operation.

Neoplasms of the Nose, Paranasal Sinuses and Nasopharynx

Neoplasms of the Nose

Innocent Growths. These occur in the nasal fossæ in the form of papilloma, fibroma, angioma, osteoma and chondroma. Focal osteitis fibrosa, leontiasis ossea and adamantinoma may also occur If small, innocent growths may be removed through the nostril but large tumours may require a sub-labial or trans-antral approach or possibly an external operation if skin is involved.

Malignant Growths. Carcinoma is rarely confined to the nasal fossæ but arises typically from the mucosal lining of the sinuses. Sarcoma may commence in the bony structure of the nose while rarely a sialoma ("cylindroma ") may be diagnosed commencing in islets of salivary tissue.

Neoplasms of the Paranasal Sinuses

The maxillary sinus and the anterior ethmoidal cells are those most commonly affected by malignant disease. Squamous-celled carcinoma arises from the mucous membrane and for a time remains localized within the sinus Osteogenic sarcoma also occurs in the upper jaw and though it is not strictly a growth of the paranasal sinuses it is convenient to consider it here since the symptoms and treatment are very much the same. Sarcoma tends to be more osteoplastic than carcinoma which is typically osteolytic. Figs. 31 13 and 14 illustrate the similarity between the two conditions.

Clinical Features. If the growth arises *from the anterior aspect* of the bone a tumour is produced which projects beneath the cheek, the tissues of which are invaded. It extends downwards towards the mouth and is readily detected through the mucous membrane. It may, however spread

deeply and involve the cavity of the antrum It causes no obstruction to nasal respiration and no epiphora except in the later stages.

If it originates *within the antrum* or as is more common, from the antro-ethmoidal region the usual signs of distension of that cavity are produced associated with a foul, and often blood-stained, discharge from the nose, within which the ulcerated surface of the growth may be seen. Epiphora is caused by pressure on the nasal duct while the growth has been known to burrow upwards along this passage and project near the inner canthus. The passage of air through the nose is impeded and the palate may be depressed The growth may also extend up the infundibulum to the ethmoidal cells and frontal sinus, or it may erode the antral roof and invade the orbit.



FIG. 31 13 OSTEOGENIC SARCOMA OF THE MAXILLA.

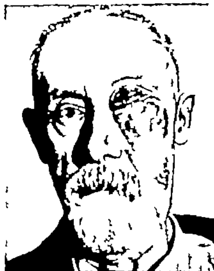


FIG. 31 14 CARCINOMA OF THE ANTRUM.

If the growth commences *behind the maxilla*, it usually springs from one of the walls of the sphenomaxillary fossa, or from the base of the skull, and is then characterized by a great tendency to spread in all directions. It may push the whole bone bodily forwards without encroaching upon the antrum sometimes it finds its way outwards to the pterygoid fossa through the pterygomaxillary fissure, or inwards to the nose through the spheno-palatine foramen, or even up into the orbit whilst more rarely it spreads down along the posterior palatine canal, so as to appear at the postero-external corner of the palate in the later stages the antral cavity is also involved, and even the base of the skull eroded. Severe pain sometimes accompanies the process, usually affecting the second division of the tri-geminal. The regional lymph nodes are involved very late in the disease those in the submandibular regions are first involved, and afterwards those in the anterior triangle secondary deposits in the viscera may also occur somewhat later The tumour follows a typical malignant course and, owing to the great vascularity of the parts, its onward progress is very rapid.

Diagnosis The only chance of improving the results of treatment lies in an early diagnosis, and to secure this a thorough and systematic nasal examination is essential in all cases of chronic obstruction to or discharge

from the nose Transillumination and radiography must not be neglected. *When the growth is sufficiently large to determine outward swelling of the cheek or palate,* or complete obstruction of one nostril or of the nasal duct with epiphora, the chances are that the disease is beyond the range of cure by operative treatment alone.

Operations on the Nose and Sinuses. Numerous operations have been devised though with the development of radiotherapy they are employed less frequently alone than in the past. The usual method is preliminary external irradiation, *followed by clearance of the affected sinuses by diathermic coagulation* and later by insertion of a radioactive applicator

Rouge's Operation. This is seldom used but consists in the detachment of the mask of the face from the maxilla by everting the upper lip and incising the mucous membrane and subjacent tissues until the nasal cavities are opened. The septum nasi is divided and the nasal cartilages are completely separated. The soft tissues of the face can then be retracted upwards and the nasal fossæ fully exposed The bleeding is always considerable and the space gained in children is slight. When the operation is completed, the mask of the face is allowed to fall back into position, union occurring *without difficulty*

Intrabuccal Operations Denker devised an operation for dealing with sepsis but this may be extended for malignant disease. By elevating the upper

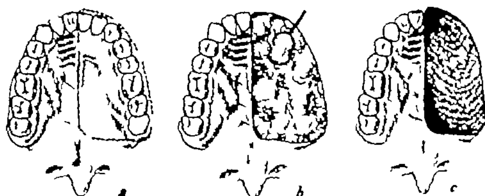
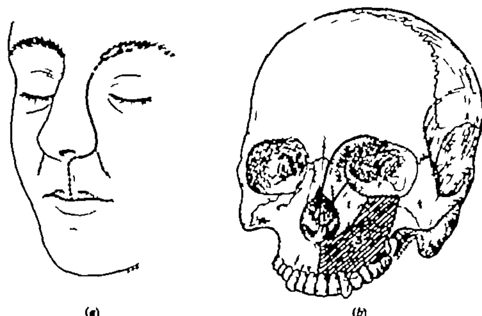


FIG. 31 15 FENESTRATION OF THE HARD PALATE.

a. The incision outlined *b.* The antrum has been opened and growth is being removed *with a diathermy loop* *c* *The cavity remaining into which the radium applicator is* fitted.

lip and opening the antrum through the canine fossa and then removing *the lateral wall of the nose, extensive growths* can be removed provided they do not extend upwards too far and in particular into the frontal sinus. In the majority of cases it is desirable to remove half the hard palate together with the greater part of the alveolus in order to gain sufficient access. After clearance of the growth by diathermy excision a large opening is left, through which a radium applicator may be inserted and through which the cavity may be inspected later for signs of recurrence. The deficiency is *rectified by an obturator attached to a denture* overlapping the soft palate and there is no disfigurement. This operation is to be preferred for almost all malignant growths of the nose and sinuses. Preliminary irradiation is advisable except where there is tension in the antrum, with severe pain or when there is marked infection.

Moure's Operation (Lateral Rhinotomy) This is an operation devised for growths which do not invade the mouth It is seldom used at the present day except when skin overlying the sinuses is infiltrated and must be excised or when the eyeball has to be exenterated The incision is made from just below the inner end of the eyebrow (Fig 31 16) down the side of the nose skirting the ala nasi the upper lip is split in the midline, and the whole cheek turned back to get free access, if the growth is extensive. The soft tissues are dissected back so as to expose the infra-orbital border and the bony margin of the anterior nasal orifice from which the cartilages are detached Incisions are made through the bone with hammer and chisel as follows (Fig. 31 16 area 1) One upwards and outwards through the nasal



(a) (b)

FIG. 31 16. LATERAL RHINOTOMY (MOURE'S OPERATION).
In (a) the extent of the cutaneous incision for a limited operation is indicated by a thick line area 1 of (b) can be dealt with in this way If the ethmoidal and frontal sinuses are invaded, the incision is carried upwards and outwards along the dotted line, and area 2 in (b) can be cleared. If a large extent of the maxilla or part of the upper alveolus is involved, the lip is split along the lower dotted line, and area 3 can be operated on and removed if necessary

process of the maxilla, or between it and the nasal bone, or further inwards if necessary a second more or less parallel to it, running from the lower border of the nasal aperture to the infra-orbital border close to the infra orbital foramen and a third joining the two and running parallel to the infra-orbital border either on the facial or orbital aspect, as is thought best. The portion of bone thus marked out, usually including a small section of the floor of the orbit, is twisted out of its bed by forceps, laying bare the lacrimal sac and canal. The amount of bone removed varies necessarily with the case but a considerable opening into the antrum and nasal cavity is secured and growths in this region can be readily removed, if need be piecemeal, without grave hæmorrhage or serious mutilation. The incisions are subsequently closed by sutures and the resulting deformity is very slight.

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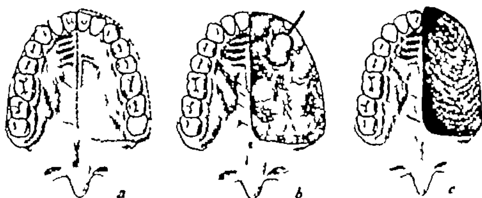


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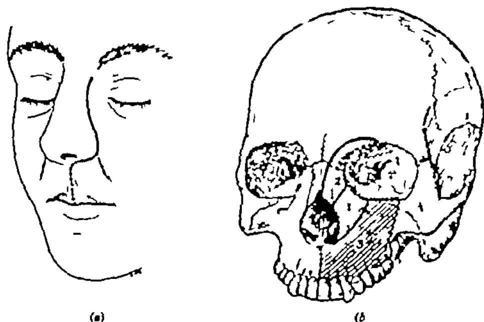


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Neoplasms of the Nasopharynx

Nasopharyngeal Fibroma. This term is applied to a neoplasm which springs from the base of the skull, either from the basisphenoid or basi-occipital. It is firm smooth, and fleshy in character when of large size, it may be lobulated. The early symptoms are usually limited to those of obstruction to nasal respiration but to this is not unfrequently added severe epistaxis owing to the vascularity of the capsule and of the overlying mucous membrane. As it increases in size, ulceration occurs, leading to a fœtid *sanious discharge, and the growth rarely remains limited to the nasopharynx.* If pushing forwards, it may lead to expansion of the bridge of the nose and separation of the eyes, which may even be made to diverge but if backwards, it may depress the velum and hang downwards. In other cases it burrows into the orbit or any of the other surrounding cavities, or may even erode the base of the skull or encroach upon the cranium. It is rare for any of these latter manifestations to occur until after the tumour has become sarcomatous, a change which sometimes occurs

The disease attacks young people, and mainly those in the second decade of life. It progresses with increased rapidity if malignant changes take place a fatal issue may be due to hæmorrhage, asphyxia, or cerebral complications.

Removal is both difficult and dangerous owing to the inaccessibility of the tumour and the risk of torrential hæmorrhage from the excessively vascular tissue of which it is composed The route of approach may be trans-antral (Denker) or better trans-palatal (Wilson) A transverse incision is made across the soft palate near its junction with the hard palate and this gives good exposure of the nasopharynx both for diagnosis, removal or irradiation treatment of either simple or malignant growths. In the case of fibro-angioma, radium or radioactive isotopes may be used either interstitially or in the form of an applicator Diathermy coagulation is a useful adjunct in treatment and this may sometimes be applied through the nostril.

Malignant Neoplasms. In rather older subjects a sarcoma may appear in the nasopharynx as a primary growth, with symptoms similar to those already described the course is rapid.

Squamous carcinoma and lympho-epithelioma also occur and may spread down the nasopharyngeal wall to appear below the soft palate the Eustachian tubes are obstructed by the growth, with symptoms of deafness at an early stage. Spread into sutures or foramina at the base of the skull, particularly the jugular foramen involves various nerves, especially the ninth, tenth and eleventh but also the fifth and sixth, with physical signs corresponding to the distribution of each Enlargement of the upper deep cervical group of lymph nodes occurs early and often before any symptoms referable to the primary have occured

Malignant growths respond to teleradium and X ray therapy and therefore this is recommended as the method of choice whether the growth be carcinomatous or sarcomatous The treatment must be prolonged and thorough and involves considerable discomfort to the patient. The fields are large in order to cover both the primary area and the lymphatics of both sides of the neck

Chapter 32

THE TONSILS AND PHARYNX

THE TONSILS

Acute Tonsillitis. This is caused by bacterial infection, sometimes of a semi-epidemic type The palate, fauces and pharyngeal walls generally participate in the inflammatory process among the organisms present are streptococci pneumococci and staphylococci, often one type in almost pure culture, but sometimes as a mixed infection. Two varieties of acute tonsillitis are described, but there is no sharp line of demarcation

Acute Parenchymatous Tonsillitis This causes general enlargement of the organ, which is dusky red in colour and painful, with obstruction to swallowing and sometimes also to breathing in those cases in which the tonsils almost meet in the middle line. The temperature is high the nodes below the angle of the jaw become enlarged and tender the tongue is covered with a thick, whitish fur the bowels are confined. The local condition may be associated with septicaemia in severe cases.

Acute Follicular Tonsillitis This differs only from the description just given by marked involvement of the tonsillar crypts, from which a yellow exudate discharges coagulating on the surface to form a false membrane, unlike that of diphtheria, however in that it does not cause bleeding when detached.

This type of inflammation more often affects tonsils of the buried variety while the parenchymatous enlargement is associated with prominent tonsils.

Peritonsillar Abscess (*Quinsy*). This may follow acute inflammation of the tonsil, with suppuration around it. The usual site of the abscess is at the upper pole infection extends outwards into the layers of the capsule through the superior tonsillar fossa. Occasionally an abscess forms in the tonsil itself Both sides are inflamed, but the abscess is usually unilateral, or if bilateral, one tonsil is affected before the other pus usually takes three to seven days to form. The palate bulges and is immobile on the affected side the uvula is swollen and œdematous, its tip pointing towards the side of the abscess. The swelling is great, so that breathing and swallowing are alike difficult the temperature is high, pain is severe, and the cervical nodes are considerably enlarged. Œdema of the glottis may result. Left to itself the abscess sooner or later points and bursts, usually in the soft palate and thus gives the patient immediate relief

Treatment General treatment consists in the administration of full doses of penicillin and sulphadimidine, or other appropriate antibiotics. There is some danger of arresting an abscess without cure so that overlong treatment with antibiotics is inadvisable. Sodium salicylate, gr 3 thrice daily and if necessary an aperient are also given. Local measures to ease the pain include the inhalation of steam from hot water (180° F) in which friars balsam (60 m.) and menthol (gr 3) are dissolved, and painting the

tonsils with a 10 per cent. solution of silver protein or a 5 per cent solution of guaiacol in glycerin three times daily the latter paint acting both as an antiseptic and as a local analgesic.

Pus should be evacuated as soon as its presence is established this should be effected by the use of sinus forceps after incision of the superficial layers with a guarded scalpel The surface may be anæsthetized with equal parts of cocaine solution (10 per cent.) and adrenaline applied on a wool swab. Fig. 32 1 indicates the point of election at which to open a peritonsillar abscess, *viz* a little internal to a point midway between the base of the uvula and the last upper molar tooth (St Clair Thomson) The opening

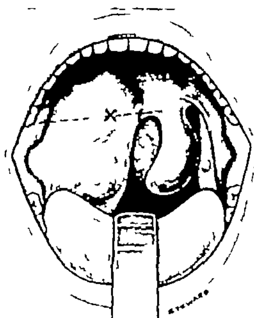


FIG. 32 1 ACUTE PERITONSILLAR ABSCESS.

The cross shows the site at which to open the abscess It is just on the medial side of a line joining the base of the uvula and the last molar tooth. (Adapted from St. Clair Thomson and V E. Negus, "Diseases of the Nose and Throat.")

is suitably enlarged downwards and towards the middle line. It is essential not to go too deep or too far outwards so as not to injure the superior constrictor or to open the deep fascia. Both before and after opening the abscess, hot fomentations may be applied to the neck and throat. Plenty of fluid nourishment is administered when the patient can swallow comfortably The fact that quinsy is very liable to recur suggests that during the quiescent interval after an attack, the tonsils should be removed.

Complications Spread of infection outside the capsule of the tonsil leads to involvement of the parapharyngeal space (Fig. 32 2) The temperature remains high and redness and swelling appear in the anterior triangle, sometimes with fluctuation. Spread to the mediastinum is a danger but a more usual sequel is thrombophlebitis in the internal jugular vein or a branch. Occasionally a vessel sloughs in the abscess, either a vein or an artery with serious hæmorrhage when the quinsy is opened Parapharyngeal abscess calls for the use of antibiotics and sometimes external incision

Chronic Tonsillitis. This often follows an acute attack, but may start as a primary condition. The tonsil is more or less enlarged and of a redder

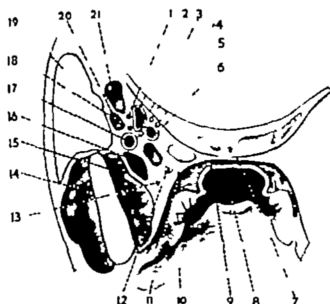


FIG. 32 2. TRANSVERSE SECTION AT THE LEVEL OF THE TONSIL TO ILLUSTRATE THE PARAPHARYNGEAL SPACE.

1. Spinal accessory nerve.
2. Internal jugular vein.
3. Hypoglossal nerve.
4. Vagus nerve.
5. Sympathetic nerve.
6. Internal carotid artery
7. Prevertebral fascia.
8. Aponeurosis of pharynx.
9. Superior constrictor muscle.
10. Tonsil.
11. Post-pharyngeal lymph node.
12. Ascending pharyngeal artery
13. Ascending palatine artery
14. Masseter muscle.
15. Internal pterygoid muscle.
16. Hyoglossus muscle.
17. External carotid artery
18. Glossopharyngeal nerve.
19. Parotid gland.
20. Stylohyoid.
21. Digastric muscle.

(Adapted from Cunningham, "Textbook of Anatomy")

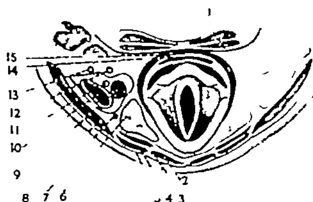


FIG. 32 3 TRANSVERSE SECTION OF THE NECK AT THE LEVEL OF THE THYROID GLAND

1. Prevertebral fascia.
2. Sternohyoid muscle.
3. Sternothyroid muscle.
4. Omohyoid muscle.
5. Pretracheal cervical fascia.
6. Thyroid gland.
7. Descendens hypoglossal nerve.
8. Sternomastoid muscle.
9. Common carotid artery
10. Internal jugular vein.
11. Vagus nerve.
12. Sympathetic nerve.
13. Phrenic nerve.
14. Pharynx.
15. Inferior constrictor muscle.

(Adapted from Cunningham, "Textbook of Anatomy")

colour than normal secretion is contained in the crypts, particularly when the tonsils are of the buried variety The condition is seen usually in children, who suffer in addition from adenoids the tonsils may be the seat of tubercles. Nodes in the neck are liable to infection and then become enlarged, and may be the site of abscess formation, sometimes tuberculous, but more often of simple inflammatory nature

Enlarged Tonsils and Adenoids. These are frequently seen in children, more often those who live in the city They are often associated with enlargement of the cervical lymph nodes and running noses due to repeated colds which result in excoriation of the nostrils. Adenoids are less common in dry warm climates The pharyngeal troubles associated with scarlet fever measles and other infective diseases often precede the development of these conditions. In consequence of the nasal obstruction children become mouth breathers and sometimes speak thickly They snore during sleep and inflammatory trouble is liable to extend to the mucous lining of the Eustachian tube giving rise to Eustachian obstruction or to middle-ear complications.

As a secondary result, tuberculous disease of the cervical lymph nodes is likely to occur probably due to infection with the bovine type of tuberculosis the nodes behind the angle of the jaw (tonsillar glands) are the first to be involved. The excised tonsil in such cases is frequently found to contain typical tuberculous giant-cell systems. Removal of the offending tonsils usually leads to resolution of the lymph node enlargement. Since defective teeth may have some influence in aggravating tonsillar affections, it is always wise before operating on tonsils and adenoids to have the teeth put in good order in a few cases this may obviate the necessity for operation Recurring attacks of acute inflammation of the tonsils are often seen it is never wise to operate for the removal of these structures sooner than three weeks after the acute stage.

Before removing tonsils and adenoids, a careful examination should be made of the nose to make sure that the mouth breathing is not due to some obstruction such as a spur or deviation of the septum. It is important, also to exclude sinusitis as a causative or complicating factor

Treatment This consists, in mild cases, in sending the child, if possible, to the seaside and by the administration of cod liver oil at the same time the tonsils should be swabbed with Mandl s paint.

In cases of chronically enlarged tonsils and adenoids, associated with marked symptoms or secondary pathological signs in neighbouring organs, the tonsils should be removed by enucleation.

Complete Tonsillectomy Enucleation may be carried out in two ways

Enucleation by the Guillotine The patient usually a child, is admitted to hospital on the previous day so as to permit a careful examination of heart, lungs and urine Instructions should have been given to the mother to administer a suitable aperient on the evening before admission. Operations on out patients are most undesirable, though sometimes performed from lack of beds. The child is anæsthetized with ethyl chloride, preferably followed by ether premedication with Nembutal by mouth is desirable. He is then placed on the operating table, lying on the back with a pillow under the shoulders. The surgeon stands on the right of the patient. The mouth is opened by means of a Doyen s gag lying on the left cheek

The instrument of choice is Heath s reinforced guillotine fairly blunt.

Holding it in the right hand, the ring of the instrument is first carried round the lower pole of the right tonsil and by a rotating and forward movement the tonsil is lifted forwards and upwards out of its bed. The tip of the index finger of the other hand is then placed on the outer attached part of the anterior pillar of the fauces, and by pressure against the ring of the instrument the tonsil is gradually everted and pushed completely through the ring. The blade is then slowly closed down by pressure of the thumb of the right hand, great care being taken not to encroach on the anterior pillar as it

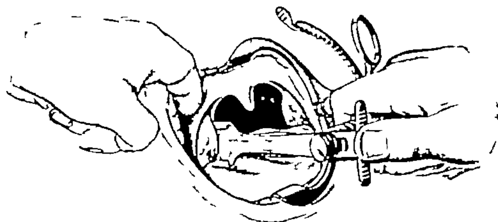


FIG. 32 4 ENUCLEATION OF THE TONSIL WITH THE GUILLOTINE.

The guillotine has been caused to engage the lower pole of the tonsil and is threaded on to it from below

The instrument is then turned sideways and the tonsil is pressed on with the operator's forefinger and is pushed through the ring. The blade of the guillotine is then closed, the pedicle of the tonsil being cut through, partly by cutting and partly by leverage.

may easily be introduced along with the everted tonsil if the digital pressure has been too vigorous. Final removal is completed by a levering movement of the hand.

The tonsil is then completely removed, the blade making its way between the layers of fibrous tissue forming the tonsillar bed. Hæmorrhage is free at first, but pressure with sponges held in forceps usually controls it. Any large bleeding vessels can be picked up later by suitable forceps and ligatured

The guillotine being now taken in the left hand the left tonsil is removed in a similar manner the actions of the right and left hands being reversed. It is a great advantage if the surgeon is ambidextrous if he can only use the right hand, it is necessary for him to stand behind the patient's head on starting the removal of the left tonsil.

The operation is completed by the removal of adenoids, and the child is rapidly turned into the prone position to allow of the escape of blood from the mouth and nose Put to bed on the side with his face more or less downwards, he soon recovers consciousness, and is encouraged to cleanse his mouth. He is advisably kept in bed for a day or two and should wash out the mouth and throat with some weak antiseptic lotion soft food is, of course, all that is permissible and ice-cream is most suitable.

Enucleation by Dissection. Various methods are in vogue when it is found undesirable to use the guillotine The essential points are first to lift the tonsil out of its bed by means of a suitable pair of vulsellum

forceps the mucous membrane is then divided between the anterior faucal pillar and the free surface of the tonsil thereby exposing its capsule The tonsil is gradually freed from its bed and removed by blunt dissection, the mucosa everywhere being divided as near the free surface of the tonsil as possible. Division of the junction between palatine and lingual tonsils is effected by the use of a snare. Bleeding vessels are then ligatured if necessary

In either operation serious hæmorrhage may occur either at the time of operation or later (reactionary or secondary) It can usually be controlled by direct pressure applied to the raw surface by means of a pad or plug of gauze, and held by suitable forceps, counter pressure of a finger from the neck may be of assistance. Morphine to keep the patient quiet, and ice to the neck, may be used in post-operative cases before suturing. Thrombin applied locally to the tonsillar fossa may stop the hæmorrhage. If bleeding is excessive, search must be made for bleeding vessels, general anæsthesia being used if necessary Ligatures are applied where required suture of the pillars of the fauces over a small roll of gauze soaked in iodoform is occasionally called for

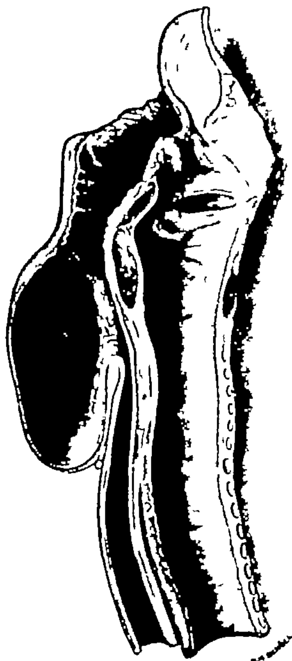
Syphilitic Disease of the Tonsil. This is now very rare in Britain. The primary chancre is seen occasionally The glandular enlargement in the neck is very marked in such cases and the course of the disease as a rule severe. Secondary ulcers of the "snail track" type (*plaques muqueuses*) *occur in this region, being usually symmetrical. In the tertiary period* a diffuse gummatous infiltration occurs, involving also the palate and fauces, and leading to pharyngeal scarring or stenosis.

Malignant Disease of the Tonsil. Such tumours are not very common but carry a bad prognosis. *Squamous-celled carcinoma* occurs as a firm indurated infiltration, rapidly spreading to adjacent parts, with early involvement of the lymph nodes It starts in the tonsil itself near the root of the tongue or in the pillars of the fauces. It presents a ragged, nodular surface with a hard margin and an area of ulceration if advanced. It is not always painful and notice may first be called to it by the enlargement of the nodes in the neck. *It runs a rapidly fatal course if left to itself* *Lympho-epithelioma* and *lymphosarcoma* of the tonsil arise in the organ itself the tumour presents a smooth, dusky red appearance, the mucous membrane being stretched over it and feeling soft and almost fluctuating. In the early stages it may be freely movable, but before long it infiltrates surrounding structures and affects the regional lymph nodes *Round-celled sarcoma* also attacks the tonsil as a primary growth, and is less limited and defined than the former In all these varieties the growth extends into the pharynx impeding deglutition and respiration ulceration with or without serious hæmorrhage may ensue indeed, the latter complication is a frequent cause of death.

Treatment Surgical excision of tumours of the tonsil is usually undesirable and sometimes impracticable from the extent of the disease and the early implication of the surrounding structures, although it has now been shown that they are more amenable to treatment than was formerly thought to be the case. It is preferable to treat cases by external irradiation, either by telecurie therapy or high voltage X-rays. The disease can rarely be dealt with by operation from the mouth

This is possible in the case of loosely encapsulated and freely movable lymphosarcomata. The capsule is divided preferably by diathermy and

PLATE 4



[Royal College of Surgeons Museum

DIVERTICULUM OF THE PHARYNX

TO FACE PAGE 776

the growth shelled out sometimes with the utmost ease and very little hæmorrhage Removal should be followed by radiotherapy but recurrence in the lymph nodes is almost certain to follow Irradiation alone is preferable In cases of carcinoma removal can also be effected through the mouth by diathermy coagulation and piecemeal removal Preliminary ligature of the external carotid artery is advisable combined at the same time with block dissection of nodes in the neck

New growths of the tonsil respond well to radiation therapy The best method is to start with telecobalt or X ray therapy and to follow this, if necessary by needles inserted through the mouth, arranged so as to irradiate the whole of the growth, or applied to the surface in the form of a plaque. Small residual areas may alternatively be destroyed by diathermy The irradiated fields also include the regional lymph node areas, but block dissection of the neck should be carried out at a later date if suspicious nodes remain.

THE PHARYNX

Acute Pharyngitis. This usually occurs with a similar inflammatory condition of the velum palati nasal mucous membrane and tonsils, and results from exposure to cold, inhalation of organisms and from general diseases of the exanthematous type, *e g* scarlet fever and diphtheria. It is characterized by redness, pain and swelling of the mucous membrane which becomes covered with mucus or mucopus. An irritable cough, perhaps with sneezing, interference with nasal respiration and great pain on swallowing, is produced by this condition. If it spreads to the Eustachian tube temporary deafness is induced. Ulceration of the velum and fauces occasionally follows. The treatment is similar to that of acute tonsillitis.

Chronic Pharyngitis. This commonly occurs in clergymen and public speakers who are called upon to exert their voices for any length of time in costers and street hawkers who shout their wares, and in those who drink and smoke immoderately In the majority of cases it is secondary to some form of rhinitis or sinusitis, or to nasal obstruction It may commence as a chronic inflammation or may follow an acute attack. The mucous membrane is more or less red and infiltrated with vessels coursing over it, and there is often a good deal of mucopurulent discharge. If the buccal side of the velum palati is affected, there is usually much less secretion than from the pharyngeal aspect, where a considerable amount of dark green viscid material may collect and cling to the pharyngeal wall, constituting scabs, which decompose and cause the breath to be somewhat offensive. In addition to the simple type, two special varieties are described

Chronic Granular Pharyngitis This is a complaint in which the lymphoid follicles scattered throughout the mucous membrane become enlarged This is especially evident behind the soft palate and upon the posterior wall and sides of the pharynx. At times the mucous membrane is thrown by lymphoid enlargement into two longitudinal columns, one on either side of the middle line, just behind the posterior faucial pillars The uvula may be elongated and hypertrophic.

Chronic Atrophic Pharyngitis This is associated with the atrophic form of rhinitis and is liable to lead to chronic laryngitis and tracheitis. The mucous membrane is smooth, dry and glazed, and the exudation forms

adherent scabs. The throat feels dry and irritable and the voice is often husky

The treatment of chronic pharyngitis varies with the condition and character of the affection In many cases the nasal trouble is the more urgent, and if it is treated effectively the pharynx improves rapidly In simple relaxed throats all sources of irritation—such as smoking, spirits and condiments—must be avoided, the bowels and digestion attended to and sprays, gargles, or local applications made use of The most useful reagents are paints containing iodine (Mandl), or guaiacol, the glycerin of tannic acid, and equal parts of glycerin and tincture of ferric perchloride, while menthol and benzoin inhalations are sometimes valuable, as also sprays of chlorbutol in liquid paraffin, or lozenges containing menthol and phenol. When the inflammation is of a severe follicular type, it may very rarely be necessary to destroy the follicles with diathermy after cocainizing the surface.

Vincent's Angina. This ulcerative form of pharyngitis is due to the presence of the *Bacterium fusiforme* and to a certain type of spirillum. It is characterized by the development of an ulcer on one tonsil, sometimes spreading to the pillars of the fauces, and occasionally elsewhere in the mouth or pharynx these ulcers may be clean, or may be covered by an abundant yellowish-white fibrinous pseudo-membrane, which is very adherent, so that its removal involves bleeding. Constitutional symptoms are very slight, but swallowing is somewhat painful. The breath is offensive.

Treatment An injection of an arsenic preparation, such as novarsenobillon, rapidly cures the disease. A solution of the same substance may be used with advantage for direct application to the tonsil Local and systemic penicillin are also effective.

Syphilitic Disease of the Pharynx. This may arise in the secondary or tertiary stages In the former it is of a superficial character such as mucous tubercles, snail-track ulcers, etc. In the latter it appears in the form of a *diffuse gummatous infiltration*, which is often of considerable consequence, both at the time and subsequently It manifests itself as a widespread nodular thickening of the mucous membrane, especially in the neighbourhood of the fauces and soft palate, which rapidly runs on to ulceration and may impede both respiration and deglutition The administration of penicillin and of arsenic or bismuth causes improvement, but the subsequent cicatrization may bind down the velum, and lead to pharyngeal stenosis of such a character as to constitute a fibrocicatricial septum, with an opening through it perhaps only large enough to allow a small bougie to pass. For such a condition much may be done the opening may be dilated by careful division of some of the bands and the passage of bougies. Of course, there is a great tendency for the opening to contract again, and treatment by bougies or a soft rubber tube must be maintained, while in resistant cases skin grafts must be applied to raw or divided surfaces. A *localized gumma* may form in the submucous tissue, may involve the posterior pharyngeal wall, and run its ordinary course with or without ulceration

Retropharyngeal Abscess. This may be acute or chronic. The acute form results occasionally from perforation through the mucous membrane, as by fish-bones, etc. usually it arises from an inflammation of the lymph nodes which are found in this situation in children and derive their lymph from the interior of the nose and nasopharynx. The pus is situated between the pharyngeal wall and the prevertebral fascia, and is therefore near the

surface and limited to one side. Distinction must be made from the *chronic* abscess which may follow tuberculosis of the spine, or disease of the bones at the base of the skull, when the pus is placed behind the prevertebral fascia, spreading across the midline. Whether acute or chronic, the abscess forms a tense elastic swelling, situated behind the posterior pharyngeal wall. In the former case it is associated with high fever and locally much redness and inflammatory œdema, which may even extend to the glottis and cause dyspnœa; in the latter where the affection is chronic, there is less local inflammatory reaction, but signs of cervical caries may be present. The abscess may burst into the pharynx, or may burrow outwards into the parapharyngeal space on either side, being guided by the prevertebral fascia, and point either in front or behind the sternomastoid.

Treatment. This must not be delayed, from fear of the supervention of œdema of the glottis. The *chronic* abscess should always be opened from the neck, as then an aseptic course can be maintained; aspiration is dangerous on account of the important structures lying in front of the abscess. If pointing in front of the sternomastoid, the abscess is opened in that situation but otherwise an incision should be made along the posterior border of the muscle, which must be drawn forwards, and the transverse processes of the cervical vertebræ defined. Possibly the abscess will be opened by the necessary manipulation of the wound. If not, a pair of sinus forceps is thrust into it in front of the vertebræ. The cavity is opened sufficiently to permit of careful curetting. The tuberculous disease must of course be treated by immobilization of the spine and the administration of streptomycin, PAS and isoniazid.

The great majority of cases of *acute* abscesses, however, may be opened from the mouth. The child is placed on the back with the head hanging far back; a gag is introduced, and a guarded knife inserted through the mucous membrane into the swelling at its most prominent point. Careful swabbing or suction should avoid any danger of aspiration of pus liable to cause pulmonary trouble.

Mixed Salivary Tumours. Sialomata may appear on one side of the pharynx. They cause bulging of the soft palate and lateral pharyngeal wall, with pushing inwards of the tonsil. They cause discomfort or dysphagia by their gradual increase in size; subsequent ulceration may cause serious hæmorrhage. Some are malignant or become so and then infiltrate locally though they seldom metastasize.

Treatment is by dissection, followed at the time of operation by diathermy coagulation or by subsequent irradiation.

Carcinoma of the Pharynx. This may start in the pharynx itself or spread there from the tonsil, base of the tongue or larynx. Primary growths arise in the pyriform fossa and on the pharyngeal surface of the epiglottis or the aryepiglottic fold. The growth is squamous-celled and ulcerates early. Lymph nodes are soon involved and the tumour gradually invades surrounding tissues, although it is interesting to note that for some time it is limited to the mucous membrane, extending superficially over it, but not involving the underlying pharyngeal muscles. Death results from general exhaustion, from hæmorrhage due to ulceration into large vessels, from interference with swallowing or breathing, from lung infections, from pressure on important nerves, or from general dissemination.

Treatment. Growths in the tonsil have been considered above. For

those on the lateral pharyngeal wall, in the pyriform fossa, or on the aryepiglottic fold, operation is undertaken by Trotter's method of lateral pharyngotomy An incision is made along the anterior border of the sternomastoid nodes are removed, preferably by complete block dissection, together with the internal jugular vein. The sternomastoid muscle is then sewn over the carotid sheath to the prevertebral muscles, and the lateral wall of the pharynx is freed Part of the hyoid bone may require removal, but if the growth is low in the pharynx, approach is obtained by removal of the greater part of the thyroid ala. The growth is dissected away with a sufficient margin of surrounding healthy tissue the pharynx is left open and a subsequent plastic operation is necessary If the growth is near the larynx, tracheostomy is desirable. Radiation therapy has been used in some cases with success needles may be carefully arranged outside the growth after sufficient exposure by external operation but a preferable method is by external irradiation using telecobalt or high-voltage X-rays.

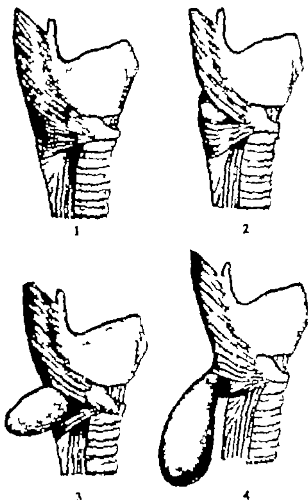


FIG. 32 5 PHARYNGEAL DIVERTICULA.
1 Normal musculature of hypopharynx, showing the arrangement of the inferior constrictor muscle.
2 Separation of circular and oblique divisions of the inferior constrictor
3 Small pouch.
4 Large pouch.

If the larynx is involved by a growth arising in the pharynx it is necessary to consider the desirability of *total pharyngo-laryngectomy* Removal of only a portion of the structures forming the laryngeal aperture presents a difficult problem in after-treatment, since secretions enter the trachea and cause infection recurrence is also greater after limited operation The complete removal of pharynx and larynx, together with the cervical œsophagus and block dissection of the lymphatic areas of the neck is described in connection with the treatment of carcinoma of the œsophagus (p 1009) Unfortunately the prognosis is unfavourable in such growths, particularly those arising in the pyriform fossæ, whether treated by surgery or radiotherapy

Pharyngeal Diverticulum. This complaint occurs in middle-aged or elderly individuals. It is in many cases the result of cicatricial contraction, or lack of relaxation, of the cricopharyngeal sphincter The pouch springs from the posterior wall of the pharynx just above its junction with the



FIG. 32 6. PHARYNGEAL DIVERTICULUM.

œsophagus, and hangs downwards alongside the gullet in the lower part of the neck (Fig. 32 5). It may be so large as to reach well into the mediastinum. *The symptoms are due to distension of the cavity with food*, which stagnates, forming a swelling in the neck which can be emptied by pressure loss of weight from want of food may result, because of pressure of the sac on the œsophagus, down which food is thus prevented from passing. The administration of a small barium meal and subsequent radiography will make clear the diagnosis, and should be followed by œsophagoscopy

Treatment In mild cases it may be sufficient to wash out the sac and dilate the cricopharyngeal sphincter under *direct vision* In severe cases it is necessary to expose the diverticulum in the neck, through a lateral incision in front of the sternomastoid, removing it, and repairing the opening in the pharyngeal wall.

Owing to the risk of infection it used to be advised that the operation

should be performed in two stages, but with antibiotic cover and meticulous technique a one-stage operation is now preferred. In closing the neck of the pouch the fascia and muscle fibres covering the mucous membrane are stripped up to form a cuff of tissue which is used to cover the defect after removal of the sac and suture of the mucosal layer By bringing this firm layer of tissues together in a double breasted fashion a good closure is effected. Drainage of the wound is advisable to avoid any collection of saliva or infected secretions in the depths of the wound. A method of operation introduced some years ago and popularized more recently consists in exposing the party wall between the pouch and œsophagus through an œsophageal speculum and then dividing this wall by means of diathermy Although there appears theoretically to be a danger of mediastinitis, yet the operation has proved to be safe and to cause only slight discomfort to the patient

Chapter 33

THE UPPER AIR-PASSAGES AND THE NECK

THE UPPER AIR-PASSAGES

Examination of the Air Passages. Before the student can diagnose affections of the upper air-passages, it is essential for him to master the use of the laryngeal mirror This consists of a circular mirror set at an angle on the end of a metal stem it is inserted into the patient s widely opened mouth in such a way that it rests against, and slightly elevates, the soft palate A beam of light is thrown on to the mirror either from an electric head-lamp on the surgeon s forehead or by reflection from a frontal mirror The patient s tongue, held with a small cloth, is drawn well forwards so as to enable the light to reach the larynx, the image of which is seen in the mirror Considerable practice is needed to attain any facility in the use of this instrument, and to recognize normal from abnormal structures. The use of 2½ per cent. cocaine to anaesthetize the fauces is often indispensable. It must be remembered that the image is inverted, so that the anterior portion of the larynx appears above and behind, but there is no reversal of the sides

It is possible to see the interior of the air-passages by the use of specula or bronchoscopes. These consist of straight tubes which can be introduced through the mouth under local or general anæsthesia the bronchoscope can be carried down to the bifurcation of the trachea and into one or other



Fig 33 1 Tomogram of Normal Larynx. The vocal folds are seen immediately above the cricoid cartilage.



Fig. 33 2. Tomogram showing Carcinoma of the Right Vocal Chord.

bronchus By this means foreign bodies can be extracted from the trachea or bronchi. Bronchoscopes with distal lighting are preferred by many while others use proximal lighting, a mirror reflecting the light from a small electric bulb.

Radiography plays a considerable part in the diagnosis of affections of these regions The presence and position of a foreign body can be determined and the existence of abscess, bronchiectasis, or a growth in the lung demonstrated. The movements of the diaphragm can be followed, and the condition of the chest wall established. Pulmonary tuberculosis can be recognized at an early stage, and the condition of the bronchial lymph nodes noted. Radiography also enables the physician or surgeon to follow the effects of an artificial pneumothorax or phrenic avulsion. Tomography is of value for outlining growths or swellings of the larynx or trachea it is also employed in various affections of the lungs, especially when solid masses or cavities are suspected.

Congenital Webs. This rare condition is seen in infants and children. The web may be thin, extending from one vocal fold to the other with obstruction of the anterior part of the glottis and sufficient in size to produce a high pitched, feeble voice and in certain cases difficulty in breathing.

Sometimes the web is thick and extensive. An operation to open the larynx, remove the web and restore a free lumen by the insertion of a skin graft, can be performed with success. Simple removal of the web with punch forceps only or by diathermy usually results in increased stenosis.

Injuries to the Larynx. Several conditions arising from injuries to the upper air-passages are described elsewhere, *e.g* fracture of the hyoid bone and incised wounds, as in cut throat (p 797). Occasionally the thyroid cartilage may be injured or fractured by direct violence as in garrotting, with resultant local pain and hæmorrhage If the cricoid cartilage is fractured there will be respiratory obstruction, sometimes to a fatal degree. As a rule no treatment is required beyond keeping the patient quiet, but should symptoms of dyspnœa arise, tracheostomy must be undertaken. If at a later date stenosis follows, restoration of the lumen is possible by opening the larynx and inserting a skin graft over a plastic tube

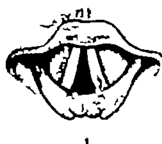
Inflammatory Diseases of the Larynx

Acute Simple and Chronic Laryngitis. These are generally associated with affections of the nasal passages paranasal sinuses or pharynx. They are seldom of primary origin unless caused by irritating gases. The acute infection is generally caused by bacteria and is characterized by aphonia (loss of voice) and cough Locally the vocal folds are seen to be hyperæmic and swollen. The treatment is similar to that for rhinitis and pharyngitis (*q v*).

Acute Œdematous Laryngitis (*Œdema of the Glottis*) This is a condition of considerable importance.

Ætiology (*a*) It is secondary either to some other laryngeal affection, such as acute catarrhal laryngitis or acute perichondritis, or more rarely to some chronic affection, such as tuberculosis, syphilis, or carcinoma or (*b*) it may extend from inflammatory conditions of neighbouring tissues, such as the root of the tongue or the submandibular region *e.g* in cellulitis or Ludwig's angina or it may be secondary to a retropharyngeal abscess. (*c*) It may also be seen in children from drinking scalding water as from the spout of a kettle or sometimes in adults from swallowing corrosives

PLATE 5



1



2



3



4



5



6

DISEASES OF THE LARYNX

1 Tuberculosis involving posterior extremities of vocal folds and inter-arytenoid region.
2. Advanced tuberculosis with ulceration of vocal fold and swelling of aryteno-epiglottic fold.
3 Mucous cysts in vallecula.
4 Simple papillomata.
5 Extrinsic carcinoma on aryteno-epiglottic fold.
6. Intrinsic carcinoma on vocal fold.

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or sustaining a wasp or bee sting of the tongue (*d*) It may result from the presence of a foreign body (*e*) It has also been known to occur as part of the nephrotic stage of nephritis. (*f*) As a local manifestation of an allergic state *e g* angioneurotic œdema or giant urticaria.

Symptoms and Signs The folds of mucous membrane extending on either side of the epiglottis both to the root of the tongue and backwards to the arytenoid cartilages become swollen and œdematous from a serous effusion into the submucous tissue The same condition involves the false vocal folds (superior thyro-arytenoid folds) extending down as far as the true folds. The process is checked at this level owing to the absence of



FIG 33 3 ŒDEMA OF THE LARYNX SEEN FROM BEHIND. (*R.C.S. Museum.*)
The base of the tongue is seen to be enlarged and swollen, and the aryteno-epiglottic folds are œdematous, so that the entrance to the larynx is represented by a mere chink.

submucous tissue, the vocal folds consisting of elastic fibres covered merely by a layer of squamous epithelium. The epiglottis becomes folded laterally upon itself as a leaf leaving only a valve like chink, which permits of expiration, although considerably checking inspiration The main symptom produced by this condition is dyspnœa, not infrequently aggravated by spasm of the glottis, and this is sometimes of sufficient intensity to destroy the patient s life. There may be some difficulty in swallowing, owing to associated œdema of the pharynx and œsophagus, and also some degree of febrile disturbance. The diagnosis is made by laryngoscopic examination, when the slit-like opening of the glottis, bounded below and behind by thickened œdematous folds of mucous membrane can be seen.

Treatment Relief may be gained by inhaling steaming water to which some friars balsam has been added sulphonamides and penicillin are indicated. Fomentations or ice compresses applied externally are also useful, especially the latter In very severe cases, particularly in children, tracheostomy may be necessary

Hyperkeratosis of the Larynx. This affects the vocal folds and sometimes

the ventricular bands. The epithelium is thickened and heaped up in regular or sometimes nodular masses. When the epithelial scales become white the disease is known as *leucoplakia*. The inflammatory changes may be associated with infections of the nose, sinuses or tonsils, but are sometimes syphilitic; malignant invasion may follow in some cases after the lapse of years.

Pachydermia Laryngis. This affects the posterior region of the glottis, with epithelial thickening over the glottis or vocal processes of the arytenoid cartilages. The disease is generally bilateral and there may be a shallow ulcer on one side with a corresponding projection on the other. This condition is not followed by malignant changes.

Diphtheritic Laryngitis. This is usually met with as an extension of a similar affection of the fauces. It gives rise to severe dyspnœa from obstruction and, if the condition does not yield to the injection of diphtheritic antitoxin, will require tracheostomy or treatment through a direct laryngoscope.

Syphilitic Diseases of the Larynx. In the *secondary* stage, mucous tubercles or superficial ulcers occasionally form in the neighbourhood of the vocal folds. No special local treatment is required. In the *tertiary* period, diffuse gummatous infiltration or localized gummata may develop, giving rise to destructive ulceration which especially affects the epiglottis and aryepiglottic folds, and may spread to involve the boundaries of the glottis. Inflammation of the perichondrium is likely to follow leading to necrosis of the cartilages. Hoarseness and dyspnœa are the chief symptoms, while considerable obstruction may be caused subsequently by laryngeal stenosis, due to cicatrization.

Treatment. Penicillin in full doses is given followed by cautious administration of iodide of potassium and mercury together with injections of arsenic or bismuth because these drugs may at first increase the swelling and thus lead to severe dyspnœa. Should urgent dyspnœa arise, tracheostomy must be undertaken. Tertiary syphilis of the larynx is at the present time very rare, owing to early and improved methods of treatment.

Tuberculous Laryngitis. This condition is almost always secondary to phthisis. If no focus is present in the lungs, deposits of lupus will be found in the nose or on the face. The disease commences at the posterior part of the larynx in the neighbourhood of the arytenoid cartilages as a submucous infiltration, which later breaks down, and leads to typical tuberculous ulcers similar to those occurring in other regions. Considerable destruction of tissue ensues in advanced cases, involving particularly the posterior region of the larynx, and even leading to perichondritis and necrosis of the cartilages. Hoarseness, cough, pain on swallowing, and perhaps a certain amount of dyspnœa are the chief symptoms arising from this affection.

Treatment. This consists primarily in the giving of anti-tuberculous drugs: streptomycin, PAS and isoniazid. As for other tuberculous affections constitutional treatment is important, and for choice in a sanatorium, while absolute silence is insisted upon. Such measures as collapse of the lung by artificial pneumothorax may be of value. Occasionally local treatment is undertaken by the laryngologist in the form of applications of the galvano-cautery. The earlier recognition of pulmonary tuberculosis and its more effective treatment is, however, reducing the number of cases of the laryngeal affection.

Acute and Chronic Perichondritis. These usually lead to abscess formation or to necrosis of the cartilage involved (*a*) The *acute* variety is pyogenic and due to injury—sometimes as the result of high tracheostomy—or to auto-infection following acute fevers, such as diphtheria or typhoid The patient complains of severe pain and tenderness over the larynx, with fever dysphagia and hoarseness Dyspnœa results from swelling of the mucous membrane œdema of the glottis may follow An abscess may point internally or externally and on opening it, the cartilage will usually be felt bare and perhaps necrosed. Treatment in the early stages is symptomatic, together with the administration of antibiotics. When dyspnœa is produced and an external swelling is present, it is well to cut down on the cartilages from outside Should this fail to relieve the dyspnœa, tracheostomy will be required. (*b*) The *chronic* variety is more often due to tuberculosis, syphilis, or carcinoma in it an abscess forms more slowly and with less constitutional disturbance, but necrosis ensues none the less here again penicillin is required. When the abscess points externally it should be opened. When a well-marked sequestrum is present, it must be removed by an external incision, and if need be thyrotomy must be undertaken. If infection of cartilage is due to a growth, it is probable that total laryngectomy will be required Distortion or stenosis of the larynx is a probable sequel possibly necessitating the perpetual use of a tracheostomy tube. A plastic operation may be required to restore the lumen and to ensure its patency the insertion of a skin graft is advisable.

Paralysis of the Larynx. This may follow injury to the recurrent laryngeal nerve during thyroidectomy or may be due to the pressure of an aneurysm of the innominate artery or aorta, a tumour in the mediastinum, or cancer of the œsophagus. Paralysis from the above causes is generally unilateral. The effect of complete paralysis of one recurrent laryngeal nerve is to produce immobility of the affected vocal fold, which lies in what is known as the paramedian position *i.e.* midway between that in which it is placed during phonation and during quiet inspiration. When due to pressure on, and not section of the nerve, the abductor fibres are involved first, leading to unopposed action of the adductor muscles, with narrowing of the glottis and serious dyspnœa in bilateral cases.

Symptoms The symptoms arising from unilateral recurrent paralysis are slight, the voice after a time, being but little modified, as the healthy fold is capable of passing across the middle line If both sides are paralysed, the voice may be slightly changed in character but severe dyspnœa is present, and thus may prove fatal, unless tracheostomy is promptly performed.

Treatment The use of a properly designed permanent tracheostomy cannula, fitted with an expiratory valve will provide free respiration with the retention of a good voice. Many operations have been designed to displace one vocal fold, so as to give a wider airway Such operations have been described by Rethi and Wittmaack, with more recent adaptation by Brian King and with subsequent modification by Kelly and Woodman.

Stenosis of the Larynx. This has been referred to under the heading of perichondritis, with a brief note as to treatment. Other causes are operations for the removal of simple or malignant neoplasms, the effect of irradiation and wounds of the larynx, sometimes self-inflicted.

Neoplasms of the Larynx

Innocent Neoplasms. *Papilloma* Multiple papillomata occur more often in children than in adults (Plate 5). They appear as wart-like masses, growing from the vocal folds and give rise to hoarseness and later to dyspnœa. They are recognized on indirect laryngoscopic examination, and in adults may be successfully removed by laryngeal forceps after the parts have been efficiently cocainized It is better however to employ the direct laryngoscope, as with special tubes and forceps it is possible to obtain a clear view of the parts and to remove the growths with precision and accuracy In children direct laryngoscopy is the only possible method Papillomata tend to recur but do not undergo malignant change.

Other innocent tumours occur rarely Such are *fibromata*, *chondromata* and *angiomata* *Mucous cysts*, though not neoplasms, may be included here.

Carcinoma of the Larynx. This usually affects elderly patients and is far more frequent in men. There are two types and these are illustrated in Plate 5

Intrinsic Carcinoma. This appears most commonly as a nodular over growth on the anterior third of one vocal fold The tumour gradually spreads, both superficially and deeply and may eventually invade the cartilages giving rise to necrosis. The growth in early intrinsic cases is unilateral, causing hoarseness As it extends, the growth gives rise to dyspnœa pain is an unusual symptom As long as the disease is strictly limited to the interior of the larynx there is but little tendency to metastasize to lymph nodes Tomography may help in localization (Figs. 33 2 and 3) Intrinsic growths are divided into cordal, supraglottic and subglottic prognosis in the last is unfavourable

Extrinsic Carcinoma. Cancer of the larynx may also commence on the epiglottis, aryepiglottic fold, or on the posterior surface of the cricoid cartilage When the growth affects the exterior of the larynx or surrounding structures, early lymphatic enlargement may follow the disease runs a more rapid course, and may destroy life by dyspnœa, pneumonia, or exhaustion from lack of nourishment. The symptoms of an extrinsic growth consist of a feeling of discomfort or of pain radiating to the ear together with pain or difficulty in swallowing and an increase in salivation. Persistent pain in the ear in patients over forty five years of age always demands a most thorough examination of the throat.

Pathology The type of growth observed in sections of a small fragment bitten out clearly with special forceps—without injuring healthy tissues—often gives valuable information. If the malignant cells are well differentiated, the rate of growth is usually slow and prognosis is good This is known as Broders's grade I and is associated with few mitotic changes in the cells. If on the other hand, the malignant cells are embryonic in type without much differentiation, growth is usually rapid and the prognosis bad as any operative procedure, even total laryngectomy is liable to be followed by early recurrence. This type of growth is known as grade IV and in it mitotic changes in the cells are marked. It is particularly sensitive to irradiation. Intermediate appearances are grouped as grade II and III with prognosis midway between the two extremes In cases of doubt, microscopic examination is necessary before the correct procedure is decided on.

Treatment (1) *Intrinsic Growths* If an efficient radiotherapy department is available it will probably be decided to refer the patient with a mobile cordal growth for treatment by external irradiation since the prospects of cure appear to be as good as those obtained by operation but with the added benefit of retention of a good or normal voice Irradiation is unsuitable for deeply infiltrating growths with fixation, for those invading the subglottic region for those following widespread hypertrophic laryngitis or for recurrent cases after operation In extensive unilateral cases and especially those associated with hyperkeratosis interstitial radium may be used according to the method recommended by Harmer and Finzi The ala of

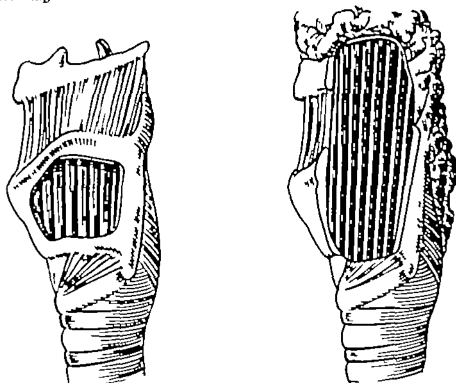


FIG. 33 4 FENESTRATION OF THE LARYNX
Left For intrinsic or glottic carcinoma. *Right* For extrinsic or hypopharyngeal carcinoma

the thyroid cartilage is removed and a palisade of four or five needles, each of 1 or 2 mg. is placed in position and left for about seven days.

In the early *intrinsic* stages thyrotomy (laryngo-fissure), and complete and wide removal of the affected area will give a good prospect of cure. An isolated growth of a low degree of malignancy on the anterior region of one fold, not extending across the anterior commissure, nor involving the arytenoid cartilage, with fairly good or unaffected movement of the fold, gives a good prognosis if a sufficient margin of surrounding healthy tissue be removed. In selecting cases for this operation particular attention is paid to the situation of the growth, to the degree of mobility of the affected fold, and in cases of doubt to the type of growth. A carcinoma which has not extended beyond the anterior commissure gives a better prognosis than one which spreads on to the other fold, although in the latter case it is possible to remove part of the second fold with success, either by simple laryngo-fissure or by excision of the anterior portion of the larynx in one

piece. If the arytenoid cartilage is involved, particularly if the posterior commissure has been reached partial removal of one fold is not likely to be effective and total laryngectomy or radiation treatment is required. Backward spread is likely to be accompanied by great loss of movement of a fold and is generally a contra indication to laryngo-fissure and irradiation.

(2) *Extrinsic Growths* In extrinsic cases removal of part or the whole of the larynx by lateral pharyngotomy median pharyngotomy total laryngectomy or pharyngo-laryngectomy together with the affected nodes, may be required, and the operation may include part of the tongue and pharyngeal wall. Radiation treatment may be preferable in certain cases. It is, however seldom effective Where the disease has spread extensively with involvement of numerous nodes, its total extirpation may not be practicable, and the prospect of cure by irradiation may be so poor that all that can be done is to treat symptoms as they arise, tracheostomy being required in certain cases. The treatment of post-cricoid growths is referred to in Chapter 32.

Operations upon the Upper Air Passages

Subhyoid Pharyngotomy This can be employed to provide access to the upper parts of the larynx. A transverse incision is made through the thyrohyoid space the pharynx is opened, and the epiglottis detached from the base of the tongue. It is a procedure that is seldom undertaken, but may be necessary for the removal of certain neoplasms

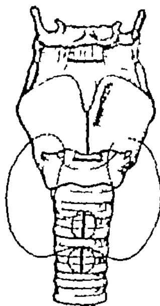


FIG 33 5

The hyoid bone is seen above, with the thyrohyoid membrane extending from it to the thyroid cartilage a transverse incision is shown in the membrane as for subhyoid pharyngotomy A vertical incision in the centre of the thyroid cartilage represents the position of laryngo-fissure. Through the cricothyroid membrane a transverse incision indicates where laryngotomy is performed. The trachea with its rings is shown partly covered by the isthmus of the thyroid gland the positions of tracheostomy openings through the second and third and fourth and fifth rings are shown by vertical lines, dotted circles representing the disc removed before insertion of the cannula.

Transhyoid Pharyngotomy In this operation the hyoid bone is divided in the middle line through a vertical incision extending from the symphysis menti to the thyroid cartilage. The pharynx can then be opened and the back of the tongue, the posterior wall of the pharynx, or the upper part of the larynx exposed. A preliminary tracheostomy is, of course, necessary

Neither of these procedures is very satisfactory in that they provide very little room, unless the lower jaw and tongue are divided in the midline (median translingual pharyngotomy)

Lateral Transthyroid Pharyngotomy (*Trotter s Operation*) The ala of the thyroid cartilage is removed after making a lateral incision along the anterior border of the sternomastoid this enables the surgeon to define the limits of the disease, and by opening the pharynx he can remove a growth on the ary-epiglottic fold or lateral border of the epiglottis, after clearing the lymphatic area involved. Preliminary tracheostomy is necessary and various remedial operations to make good the defects caused by the removal of the pharyngeal wall may be called for

Thyrotomy (Laryngo-fissure). In this operation the thyroid cartilage is divided vertically in the midline This route may be used for the removal of tumours of an innocent nature, or for a localized intrinsic carcinoma of the vocal fold. An incision is made in the middle line from the upper border of the thyroid cartilage to the suprasternal notch. Tracheostomy is performed, either below or at the level of the isthmus of the thyroid gland in the latter case the isthmus is divided. The thyroid cartilage is stripped bare of its perichondrium on the side of the growth, and then by means of special saw and shears is cut through from below upwards The outer blade of the shears is made to cut the cartilage a little to the unaffected side to give good clearance the inner blade is passed through the crico-thyroid membrane and enters the glottis from below if kept rigidly in the middle line, it neither injures the growth nor damages the vocal fold and other tissues on the sound side. The larynx is held open with retractors and the trachea is packed off above the tracheostomy tube the vocal fold and ventricular band, with the underlying muscles and perichondrium are then stripped off the thyroid ala as far as necessary even on to the cricoid ring. The ala thus separated is then removed to give easier access to the interior of the larynx. Using specially curved scissors, three cuts are needed to remove the tumour one through the ary-epiglottic fold a second below the vocal fold and the third behind the growth, taking away a small portion of the vocal process of the arytenoid. The growth is thus removed completely with a sufficient area of healthy tissue around it. Any bleeding is controlled the tracheal pack is removed the tissues are accurately sutured and a dressing applied. The tracheostomy tube is removed after eight to twenty four hours.

This method of treating intrinsic cancer of the larynx was popularized by Sir St. Clair Thomson. The after-results proved successful, the patient being able to speak audibly but as already mentioned the good results of irradiation therapy have made this operation less popular

Total Laryngectomy This mutilating operation is almost never under taken except for malignant disease and then as a rule when it is deeply infiltrating, when it has an extensive subglottic or supraglottic extension or involves both sides. So long as the growth is intrinsic there is hope of a good result but when it has spread beyond the laryngeal limits the

prognosis is much worse In favourable cases, although the patient loses all power of normal phonation he speaks with his œsophagus, or can cause a reed to vibrate while articulating with the mouth and lips. Improved diagnosis on the part of practitioners is bringing patients for operation at an earlier date, and laryngectomy is less frequently employed than formerly It must suffice to state that double skin flaps, or a single flap with its base above are separated and the larynx freed in front and laterally The thyrohyoid membrane is cut through, usually after detachment of the hyoid bone, and the larynx is removed from above down, being cleared from its attachments to the constrictors. The trachea is cut across below the third or fourth ring on the slant so as to enable its margins to be stitched to the edges of the skin, thus establishing a permanent opening. The rent in the mucous membrane of the pharynx is closed by sutures, the divided inferior constrictor muscles are drawn together the skin incision closed and provision left for free drainage. It is possible, in most cases, to secure healing by first intention. If the disease has spread beyond the laryngeal limits, the operation must be suitably modified, and becomes increasingly difficult. When a growth involves both larynx and pharynx, extensive removal is necessary with immediate or subsequent operation for the repair of defects in the food passage (pharyngo-laryngectomy).

Laryngostomy This is rarely done except for the relief of dyspnœa arising from some sudden obstruction to respiration It is thus to be looked on as *an operation of urgency* It is a rare alternative to tracheostomy in cases where the entrance to the larynx is obstructed by a foreign body for spasm of the glottis, or for accumulations of blood in the neighbourhood of the larynx during an operation It is readily performed by making an incision over the situation of the cricothyroid membrane, which is then divided transversely along the upper border of the cricoid cartilage, the sternohyoid muscles being, if necessary drawn aside and a tube inserted. Whenever there is time to operate deliberately tracheostomy is the better practice, since a tube inserted through the cricothyroid space gives rise to considerable irritation and perichondritis, and the voice or breathing may be interfered with by the contraction of the cicatrix. A special tube is required, the lumen of which is not circular but oval and flattened from above downwards.

Tracheostomy The trachea consists of from sixteen to twenty rings, of which six or seven are above the level of the sternum. The isthmus of the thyroid gland generally covers the third and fourth rings the trachea may be opened either above below or behind the isthmus, which is, if necessary divided, or pushed up or down. Tracheostomy is required in any condition of serious obstruction to respiration, occasionally for œdema of the larynx, and for diphtheria for stenosis tumours, and some forms of paralysis of the larynx occasionally before or after the removal of foreign bodies or for compression of the larynx or trachea by external tumours such as a malignant thyroid gland It is also undertaken as a preliminary measure in operations on the pharynx or larynx, in which there is any likelihood of asphyxia or secondary septic pneumonia, owing to the entrance of blood or septic discharges into the air-passages. If tracheostomy is performed too near the larynx, there is great danger of perichondritis, followed possibly by death, or by subsequent laryngeal stenosis, due to obstruction or to fixation of the arytenoid cartilages because of arthritis, with

consequent loss of movement of the vocal folds In such a case the tracheal cannula must be worn permanently Therefore, the opening should never be so high as to injure the cricoid cartilage, or to divide the first ring of the trachea it should be at the level of the third, fourth or occasionally fifth ring of the trachea. The former distinction between high tracheostomy above the isthmus of the thyroid and low tracheostomy below it loses meaning, as the arbitrary boundary fixed by the gland can be ignored A patient should never be allowed to die of asphyxia because the operator finds difficulty in opening the trachea low down air should be let into the wind pipe at all costs but if the first tracheal ring or cricoid cartilage has been damaged it is important that as soon as tranquil respiration is established a second opening should be made well away from the larynx and the cannula transferred

The Emergency Operation This is performed as follows The patient is placed on the back with the shoulders somewhat raised and with a sandbag or pillow beneath the neck so as to throw the head backwards and put the structures on the stretch. If it is practicable to insert an intubation tube or a small bronchoscope before operation, the procedure is greatly facilitated No anæsthetic may be required if the patient is partially asphyxiated, but usually it is advisable to employ local infiltration with procaine or lignocaine. General anæsthesia should be avoided if possible, because of the danger of increased dyspnœa at the time of operation and also for fear of postoperative lung complications. The head is held exactly in the middle line and the surgeon feels for and identifies, the cricoid cartilage. The incision extends from the top of the cricoid cartilage to the top of the sternum The superficial fascia is divided, and the interval between the sternohyoid and sternothyroid muscles made out, so as to enable them to be separated one from the other The edges of the wound are drawn aside by blunt hooks, which should both be held by one assistant, so as to ensure equable traction

The isthmus of the thyroid gland should be pushed either up or down, after the fascia along its lower or upper border has been transversely incised if this is inconvenient, it is divided and ligated. The trachea is thus clearly exposed, and should be fixed and steadied by inserting a sharp hook into the lower border of a tracheal ring. The wound is freed from blood, and after the injection of about 5 drops of 2½ per cent. cocaine—except in very urgent cases—the trachea is opened by cutting through one of the rings from below upwards, a complete disc being removed, sufficiently large to admit of the introduction of the cannula, unless the urgency of the case prevents this refinement. A deep inspiration is usually taken at once, with or without coughing, and if the operation is undertaken for diphtheria the surgeon must be careful not to let any membrane which may then be expelled enter his eyes, nose, or mouth. The use of suction is a great advantage. The insertion of the tube is in many cases easy—particularly if a disc has been removed in others it is a matter of some difficulty Anything which suffices to separate the lips of the tracheal incision *e g* the handle of a scalpel introduced and turned, a couple of hooks, or dressing forceps, will form an efficient guide for this purpose. The breathing soon becomes quiet and regular and the tube is adjusted and fixed in position by tapes passed through lateral openings in the face-plate, and tied round the neck. The wound is dressed with one or two layers of tulle gras beneath the plate.

When very *low* tracheostomy is performed, the inferior thyroid veins

come into view and may cause trouble if they are distended with blood as is so frequently the case in patients suffering from dyspnœa. They must be held aside by hooks, or divided between ligatures, and the deep layer of fascia behind them incised so as to expose the trachea, which is cleared, fixed, and opened in the same way as described above the left innominate vein may be in danger and occasionally the innominate artery also may be near the zone of operation When there is no extreme urgency as with most cases of malignant disease it is less distressing to the patient if he reclines, instead of lying flat the use of a mechanical headrest is an advantage

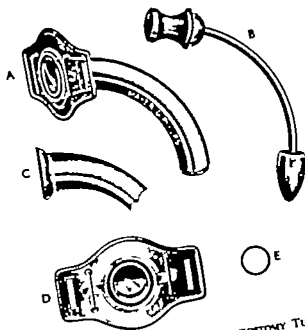


FIG. 33 6. THE NEGUS TRACHEOSTOMY TUBE

A The cannula complete with inner tube and valve.
B. Introducer
C Detail of inner tube to show the expansion of the end lying outside the trachea
D Front view with valve open.
E. Lumen of the inner tube, equal to the lumen of the valve.
When expiratory passage of air is obstructed an open inner tube is used.

Many different forms of *tracheostomy tube* have been used from time to time, but the essential elements are a double cannula, the inner portion of which can be readily removed and cleansed it should always be slightly longer than the outer in order to prevent any plug of mucus being left within the outer tube on removal of the inner A cannula made in the form of the arc of a circle is very satisfactory if its length and curvature are correctly designed. Whatever variety of tube is preferred by the surgeon it is essential to have more than one size to hand as the calibre of the trachea and the depth at which it lies vary much in different patients. The tube illustrated is valved and this is of particular use for patients who have great difficulty in inspiration alone as occurs with double abductor paralysis. In most cases an open inner tube is required.

Difficulties of the Operation (*a*) It is not always easy to find the trachea

especially in the necks of fat children or where there is an unduly large thyroid isthmus, or possibly a projection of the thymus gland into the neck It is here most essential to keep in the middle line although occasionally the trachea may be displaced from its normal position by some external growth and can then be found only by careful exploration with the finger (*b*) Hæmorrhage is generally troublesome It is usually venous in character arising either from the anterior jugular vein or from the inferior thyroid plexus. Should much blood be inspired it may lead to aspiration pneumonia at a later date. The use of a suction pump during the operation is of great assistance. (*c*) The possibility of the entrance of air into veins must not be overlooked, although it is an uncommon accident, since the intravenous pressure is usually increased (*d*) considerable damage may be done by incautious use of the knife especially if the operator forgets to fix the trachea with a shark hook before opening it. The knife should always be entered with its back towards the episternal notch and the incision made from below upwards. In a child the trachea is small and if it is moving rapidly up and down as happens in urgent dyspnœa or if the child is restless, the difficulty is manifestly increased. Many accidents have happened from this cause e g wounds of the large veins or arteries of the neck, or even of the œsophagus or bodies of the vertebræ (*e*) The introduction of the tube is a matter of no difficulty if the surgeon takes the precaution of not removing the hook until this is satisfactorily accomplished

After treatment The patient is placed in bed, in a room kept at a uniformly warm temperature (65° F). Draughts are excluded by curtains, and nothing, except a thin veil of gauze, should be placed over the entrance to the tube so that respiration may not be hindered nor the expectoration of mucus, false membrane, etc., prevented The inner portion of the tube is removed by the nurse and cleaned frequently any inspissated mucus upon it being readily removed by the use of a solution of bicarbonate of soda (1 g. to 20 ml.). The outer tube does not require changing sooner than fourteen days after insertion. Should the respiration become impeded by a collection of mucus in the trachea, a rubber catheter connected to a suction pump will be of assistance in clearing the passages.

The tube may give rise to ulceration of the trachea if it is not correctly shaped. In cases of doubt a lateral radiograph is of value in this respect

Intubation of the Larynx. The passage of a tube through the mouth may be achieved with the aid of a specially contrived introducer Tracheostomy is, however preferable in cases of laryngeal obstruction or as an alternative clearance of the obstructed airway may be done by direct laryngoscopy

Foreign Bodies in the Air Passages

Any part of the respiratory tract may be partially or completely obstructed by the presence of a foreign body the effect of which may be of greater or less gravity according to its situation, character and size

In the Nasal Passages. This is described on p 749

At the Entrance to the Larynx. Obstruction here may be due to attempts to bolt large masses of food which, becoming impacted may cause immediate death. A person, eating a meal voraciously turns black in the face and falls off his chair dead. A similar result has followed such a foolish act as attempting to swallow a billiard ball. If the obstruction is not complete, as when a large denture becomes impacted, dyspnœa is caused the symptoms

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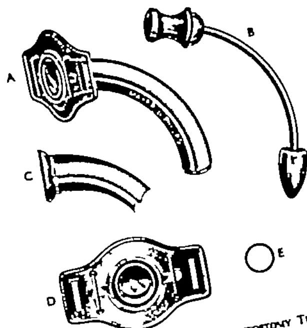


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rapidly increasing owing to œdema of the submucous tissue of the glottis. Accidents of a similar nature may occur during anæsthesia, an epileptic fit, or drunkenness, substances such as a denture or a mass of vomited food blocking the entrance to the larynx.

Treatment This is a matter of urgency since there is no time to lose The mouth should be forced open by the handle of a fork, or anything suitable that happens to be near and the finger swept round the pharynx so as to dislodge the foreign body Care must be taken not to push the object still further into the laryngeal aperture Failing removal, laryngostomy or tracheostomy must be performed and artificial respiration, if necessary instituted In less urgent cases there is time to remove the substance from the mouth by direct laryngoscopy

In the Larynx. A foreign body enters the larynx by inhalation during a deep respiratory effort, when the glottis is widely open Anything large is likely to be stopped above the larynx, while smaller objects usually pass into the trachea or bronchi Small coins, buttons, nutshells, or pins, may however be arrested in this region. Laryngoscopic and radiographic examination should reveal the situation of the intruding body

Treatment The foreign body should be removed through the mouth with grasping forceps, passed through a direct laryngoscope, the head of the patient being lowered to prevent the foreign body falling into the trachea if dislodged when not firmly grasped.

In the Trachea. To lodge in this situation a foreign body must be small enough to pass through the rima glottidis, and not too heavy otherwise it will drop into one of the bronchi it may become impacted, if it has jagged edges, but more often remains free. Fragments of nuts are among the objects most likely to lodge here

Symptoms Obstruction, irritation and inflammation dependent on the size and nature of the object are caused. At the moment of arrival of the foreign body the patient will suffer from a severe attack of spasmodic dyspnœa and coughing of temporary duration. Later on similar attacks may be induced if the foreign body moves, particularly if it is light or of a vegetable nature it can be coughed up against the lower aspect of the vocal folds, and death has even resulted from œdema of the glottis The irritation of a vegetable type of foreign body in the trachea produces acute tracheo-bronchitis with frothy expectoration and spasmodic cough Radiography will reveal opaque objects and will indirectly show the position of vegetable foreign bodies through signs of partial obstructive emphysema limitation of movement of the diaphragm and narrowing of the mediastinal shadow

Treatment A bronchoscope should be introduced so that the foreign body may be seen and by suitable forceps secured and removed If such appliances are not available, a low tracheostomy must be performed if dyspnœa is severe particularly if the object is of vegetable nature As soon as practicable the patient is conveyed to some centre where the foreign body can be removed by bronchoscopy

In a Bronchus. To become so impacted the foreign body must be sufficiently small to pass through the rima glottidis, and heavy and smooth enough to drop down the trachea the most common *non-vegetable* articles are buttons, pebbles, slate pencils, pins, or beads, teeth or part of the inner cannula of a tracheostomy tube The right bronchus is more often obstructed, as it is more in a direct line with the trachea, and is the larger Symptoms

similar to those already described manifest themselves *if* obstruction irritation and inflammation The obstruction is twofold immediate as a result of the passage of the intruder through the glottis a condition due more to spasm than to mechanical causes and late as a sequel of lodgment in the bronchus. *Vegetable substances* like orange pips and melon-seeds or pieces of nut may lodge in a main bronchus or one of the branches in such a case irritative tracheobronchitis arises in addition to the signs of obstruction of part of the lung. The obstruction is at first partial and more or less valvular in character allowing entrance of air during inspiration, but preventing its exit Hyper resonance and absence of breath-sounds result Obstructive emphysema of a lobe or a whole lung is thus produced Radiography shows obstructive emphysema flattening of the diaphragm on the affected side and displacement of the mediastinum on respiration The swelling of the mucous membrane later makes it complete Subsequent collapse of that portion of the lung supplied by the affected bronchus is induced as indicated by dullness and the absence of breath-sounds. Vegetable substances produce such acute tracheobronchitis that they soon kill the patient if not removed non-vegetable objects, on the other hand, may lie in the lung for months or years without producing symptoms, but lung abscess or bronchiectasis, with purulent sputum, will appear eventually Sometimes the abscess may extend through the lung substance to the pleura setting up a localized empyema. In other cases bronchiectasis appears, the patient finally dying of exhaustion

Treatment It has now been demonstrated conclusively that except in cases where a foreign body lodges on the top of the larynx and causes immediate suffocation it is possible to permit the patient to travel to some centre where expert help is available. After the first spasm of coughing the patient who has inhaled a foreign body of non vegetable type is more or less confortable, and no immediate ill results arise In the case of vegetable objects however œdema of the glottis may necessitate urgent tracheostomy The foreign body is carefully localized by examination of the lungs and X-rays, and it is wise (as advised by Chevalier Jackson) to practise removal of a replica of the foreign body through the bronchoscope before dealing with the case by removal under direct vision, or on rare occasions, under fluoroscopic guidance. Cases of deeply lodged and irremovable foreign bodies with considerable disorganization of the lung, may call for lobectomy

THE NECK

Cut Throat. Injuries of the neck are commonly met with in cases of attempted homicide or suicide and vary much in severity according to the extent and position of the wound. A right handed suicide usually cuts his throat from left to right, and therefore the incision is bold and clean on the left side tailing off towards the right in a left handed suicide the incision runs in the opposite direction A homicidal cut throat varies in its direction according to whether it is done from behind or in front. If the front of the neck is mainly involved the air-passages are laid open and the patient s life though much endangered, is not necessarily destroyed, the vessels being protected by their more posterior position If *however* the wound chiefly affects the side, the great vessels and nerves may be divided, and death from hæmorrhage is likely The course and treatment of the latter class of case

require no particular notice since the general principles relating to all wounds must be adhered to Where, however the air-passages have been opened, special complications arise, requiring suitably modified treatment.

Wounds Involving the Air-passages. For practical purposes the wound may be situated at four different levels (*a*) above the hyoid bone, encroaching on the base of the tongue (*b*) through the thyrohyoid space, the most common situation (*c*) in the larynx and (*d*) opening or dividing the trachea.

Immediate Effects These are shock, hæmorrhage asphyxia or the entrance of air into veins. When above the hyoid bone, the root of the tongue and submandibular region are involved, and hæmorrhage from the lingual or facial arteries or their branches follows if the wound extends far enough, the main vessels are divided and death results In the less severe cases the patient runs considerable risk of being suffocated by the epiglottis and base of the tongue falling back over the larynx. Much difficulty will be subsequently experienced in feeding the patient, owing to impairment of the movements of the tongue When the thyrohyoid space is opened the facial and lingual arteries are again in danger as also the superior thyroid artery The base of the epiglottis is divided, and portions of mucous membrane around the entrance of the larynx may be detached and cause obstruction to respiration. Blood may also trickle down the larynx into the trachea and lead to asphyxia In both this and the preceding variety much pain and difficulty on swallowing will be experienced Wounds of the larynx are usually transverse, and not very extensive owing to the resistance offered to the knife by the cartilage. The thyroid gland may be wounded and bleed freely otherwise there is but little hæmorrhage. Blood may find its way into the trachea or lungs, and asphyxiate the patient When the trachea is involved, the common carotid and inferior thyroid vessels are very liable to be wounded giving rise to severe if not fatal, hæmorrhage. Asphyxia may be brought about by displacement of the severed portions of the tube or from the entrance of blood into the air passages, while air may also be sucked into opened veins. The recurrent laryngeal nerve may be divided

Secondary Effects Following cut throat injuries, these are mainly inflammatory The wound is likely to become infected giving rise to a cellulitis which may spread down to the mediastinum or to œdema of the glottis. Secondary hæmorrhage also arises from this cause. Inflammation of the air-passages, *e.g.* tracheitis, bronchitis or bronchopneumonia, frequently follows as a result of the admission of septic material, such as food, decomposing blood-clot or discharges. The patient may become cyanosed from these causes, and in consequence of the partial asphyxia the sensibility of the mucous membrane of the glottis is diminished allowing the passage into it of food which may appear in the wound in some cases this may have arisen from division of the superior laryngeal nerve but the depth at which this structure is situated in the neck makes it difficult for this to be divided without injury to the main vessels. Surgical emphysema, or the entrance of air into the cellular tissues, may also follow a wound of the air passages It is not limited to the neck, but extends to the trunk, being recognized by the puffy distension of the part, and by a soft crackling crepitus elicited on pressure. It is of no great consequence and usually disappears in a few days

Treatment The first essential is the arrest of hæmorrhage Occasionally

the bleeding is so deeply situated that it is necessary to tie either the external or the common carotid artery General oozing from the surface must be attended to for fear of blood being sucked into the air passages Every effort should be made to render the wound aseptic damaged portions of skin are excised as also hopelessly injured muscle if there is a reasonable prospect that asepsis has been attained the wound may be closed by sutures in the ordinary way Where, however asepsis is doubtful the wound should be packed with gauze soaked in flavine and suture deferred for a few days Antibiotics are administered by intramuscular injection

The treatment of the air passages varies with the site of the lesion If the trachea has been roughly divided the portions should be steadied by a stitch on either side and a tracheostomy tube inserted for a few days when cleanly cut suture without the use of a tube can be safely permitted When the wound involves the larynx, it is desirable to close the opening at once, since the larynx does not readily tolerate the presence of a tube if necessary it is better to perform a tracheostomy When the wound involves the thyrohyoid space, or is situated above the hyoid bone, it is quite safe in many cases to close the wound layer by layer after carefully disinfecting it The mucous membrane is first dealt with by stitches which do not penetrate its whole thickness. If the epiglottis is divided it must be accurately sutured If there is any doubt as to the advisability of this proceeding, a tracheostomy is first performed and then the wound closed as far as possible. If necessary skin grafting should be undertaken.

In every instance the head should be flexed on the chest and in suicidal cases a careful watch maintained to prevent the patient tearing the wound open. Loss of blood is dealt with by blood transfusion. Feeding should always be undertaken through a nasal tube passed into the œsophagus whether that structure is wounded or not and this should be continued until the patient's natural powers of swallowing are restored. Penicillin should always be given prophylactically to avoid septic complications.

Complications The following may result from a cut throat injury (*a*) An aerial fistula is a persistent abnormal communication between the air passages and the external air and occurs most often in the thyrohyoid space, the skin and mucous membrane becoming continuous one with the other around the margins of the opening. In some cases it may be closed but if laryngeal stenosis or adhesions are present it must be left alone for a time until these conditions have been treated. The operation consists in separating the skin from the mucous membrane and in order to accomplish this, the external wound must be enlarged vertically The edges of the mucous membrane are then pared and stitched together horizontally The external wound is either closed vertically or left partially open and packed (*b*) Laryngeal or tracheal stenosis, due to the cicatrization of wounds in these regions, may necessitate the constant use of a tracheostomy tube (*c*) Aphonia may arise from division of the recurrent laryngeal nerve and is occasionally permanent. (*d*) Œsophageal or pharyngeal fistulæ may also in rare instances complicate the healing of an extensive wound in the throat, but tend to close of themselves and require no special treatment.

any other region where developmental rudiments are found As already mentioned they may develop laterally from the branchial clefts, but may also be found in the middle line, or in connection with the thyroglossal duct.



FIG. 33 7 MEDIAN SECTION OF TONGUE, LARYNX, AND TRACHEA, SHOWING THYROGLOSSAL DUCT EXTENDING FROM THE FORAMEN CÆCUM OF THE TONGUE DOWNWARDS BEHIND THE HYOID BONE AND IN FRONT OF THE TRACHEA TO THE ISTHMUS OF THE THYROID. (*R.C.S Museum*)
A small cyst in the centre of the tongue is also represented.

Thyroglossal Cysts The thyroglossal duct consists of a tubular out growth from the embryonic pharynx passing downwards behind the body of the hyoid bone in front of the larynx and trachea as far as the isthmus of the thyroid gland, which is subsequently developed from it This unites with the lateral lobes, which in turn spring from the deeper parts of the branchial arches. The upper end of the duct is situated at the foramen cæcum of the tongue and thence traverses the substance of that organ between the genio-hyoglossi muscles to reach the hyoid bone the lower end is represented by the pyramid of the thyroid isthmus. The whole of this tube disappears under ordinary circumstances If however the upper part remains unobliterated a cyst may originate from it, placed either in the substance of the tongue or immediately below it. If the lower portion remains patent, a cyst develops containing mucoid fluid, which however is not present at birth. If it bursts spontaneously usually as the result of infection, or is opened, a so-called *median cervical fistula* results. Accessory thyroid growths of an adenomatous nature may develop from any part of the duct but especially from the lower end they are quite innocent in nature

Cystic Hygroma This is sometimes congenital, but may also be acquired It consists of a multilocular swelling, the spaces composing it being due to dilatation of lymphatic spaces and filled with lymph It is in fact a lymphangioma. The tumour is often of considerable size and forms a soft, lobulated swelling, often with deeply placed intermuscular prolongations. It may produce great deformity and marked pressure effects The skin over it may be occupied by dilated capillaries or lymphatics. Unless extending to inaccessible parts, such as the superior mediastinum it should be dealt with by excision

Acquired Lesions of the Neck

Acquired Cysts of the Neck. *Sebaceous Cysts* These develop in the skin as elsewhere and need no separate notice

Bursal Cysts These occur in connection with the larynx and hyoid bone. There is usually a bursa over a prominent pomum Adami and this may become enlarged and distended with fluid. Another bursa the subhyoid bursa also exists between the back of the hyoid bone and the thyrohyoid ligament and may be mistaken for a thyroglossal cyst. Its long axis however lies transversely and it is incorporated in the soft tissues beneath the hyoid bone, moving on respiration. In doubtful cases a microscopical examination of the lining wall will quickly settle the diagnosis since if it is bursal in origin it is lined with endothelium, whilst if it is thyroglossal it is lined with epithelium In the former case incision and drainage usually suffice to bring about a cure although excision is preferable in the latter case it is essential that it should be entirely removed This usually necessitates the careful dissection of the cyst or thyroglossal sinus, with the removal of the body of the hyoid and the tract must be excised up to the foramen cæcum If this is not done a fresh sinus will form

Unilocular Serous Cysts These are sometimes met with in the lower part of the posterior triangle. They contain serous fluid with perhaps an admixture of blood Their origin has not been defined with any certainty but they are probably due to a dilatation of the lymph spaces, and are best treated by excision.

Hydatid Cysts These may also occur in this region.

Other Cysts Cystic degeneration may arise in the submandibular salivary gland, in the thyroid gland itself or in a lymph node. In the last of these the most likely cause is either tuberculosis or malignant disease. Cysts lined by gastric mucosa may arise in the submandibular region unless completely excised they rapidly regrow

Cervical Lymphadenitis. About one third of all the lymph nodes in the body are situated in the neck Consequently it is to be expected that a large number of different conditions may cause their enlargement. Broadly these fall into two groups (*a*) Infective and (*b*) Neoplastic. Diseases of the lymphatic system are described in Chapter 9 A brief account of the conditions which may cause enlargement of the cervical lymph nodes, however is not out of place.

Acute Cervical Lymphadenitis In children this is nearly always secondary to tonsillitis but infection of the scalp, especially by *Pediculus capitis* must not be overlooked. The nodes below the angle of the jaw are most commonly affected and a fluctuating abscess often forms rapidly without much constitutional disturbance. The infection is commonly staphylococcal and may respond to penicillin therapy but if fluctuation is elicited the pus should be let out through a small incision in addition to chemotherapy Fomentations are best avoided as they make the skin soggy

In adults acute lymphadenitis also follows infections of the teeth, mouth or throat but less commonly progresses to abscess formation. If this does occur the possibility of secondary infection of chronically enlarged nodes (*e.g* tuberculosis or malignant disease) should be considered.

Tuberculous Lymphadenitis The condition usually begins in childhood and compared with tuberculosis elsewhere is relatively innocuous. With the

pasteurization of milk the disease is becoming far less common. Tonsils, adenoids and teeth are the portals of entry The upper deep cervical nodes are affected in 50 per cent., other groups in order of frequency being those of the posterior triangle, the submandibular the lower deep cervical and supraclavicular The parotid nodes are very rarely involved.

At first the nodes are small mobile, discrete, *painless and are not tender* Soon one or more become caseous but the pus is confined by the capsule of the node When this bursts the pus remains below the deep fascia but sooner or later this also gives way at one point and the pus spreads beneath the superficial fascia forming the characteristic " collar-stud " abscess. The final stage is reached with softening of the skin and the development of one or more sinuses.

As with tuberculosis elsewhere, *spontaneous healing tends to occur by* fibrosis and later by calcification of the nodes General treatment is of the utmost importance and diseased tonsils and adenoids should always be removed before considering radical surgical treatment. The anti tuberculous drugs have rendered this less necessary but in many cases it still has a place. Palliative treatment includes aspiration of the abscesses, which is seldom of much use and curettage of the sinuses, which has almost nothing to commend it. *Complete dissection of a localized group of nodes, preferably* through a transverse incision is the method of choice, and this should be done under antibiotic cover Contra-indications to surgery are the presence of active disease in the lungs or elsewhere or widespread involvement of all the nodes in the neck.

Actinomycosis The neck is the commonest site for this condition to occur the ray-fungus gaining entry possibly through a tooth socket. *Induration in the submandibular region with multiple sinuses* (Fig. 1 12) and later secondary infection produces a characteristic picture. Subcutaneous and subfascial spread occurs but pain is not a feature of the disease. The diagnosis is confirmed by the finding of the fungus in the sulphur granules exuded in the discharge

Other causes of Infective Lymphadenitis The acute specific fevers of childhood, *e g* scarlet fever German measles and diphtheria all give rise to cervical lymphadenitis. *Infective mononucleosis or glandular fever* should be remembered Many tropical fevers such as trypanosomiasis and plague similarly are associated with enlarged nodes in the neck.

Malignant Lymphadenitis Neoplastic involvement of the cervical nodes may be primary or secondary Among the former lymphosarcoma and Hodgkin's disease feature prominently and are described in Chapter 9 Secondary metastases occur from any growth of the face, mouth upper air passages or pharynx. But *neoplasms* of the breast, bronchus, stomach, alimentary canal or testis may all disseminate to the supra-clavicular nodes especially that on the left side beneath the insertion of the sterno-mastoid muscle (Virchow's gland)

Cervical Neoplasms. These may be innocent or malignant and in general do not differ from those in other parts of the body There are a few however which may be mentioned as occurring particularly in the neck.

Lipoma A diffuse lipomatosis may occur in heavy beer drinkers and others forming a loose fatty collar around the neck.

Squamous and Basal-celled Carcinoma Both these occur on the skin of the neck though not so commonly as on that of the face

Chromaffinoma This rare tumour may arise from the carotid body Occasionally such tumours spread slowly and behave as innocent neoplasms but usually are very malignant growing from the deep aspect of the bifurcation of the common carotid They have been called potato tumours because of their resemblance on section to a raw potato The common carotid and its two branches become deeply embedded in the tumour which is markedly movable transverse to the direction of these vessels but fixed in their longitudinal axes. Nerves and muscles are eventually infiltrated but metastasis is rare. Another name applied to this type of tumour is a *chemodectoma* since it is said to be composed of pH receptor cells Extirpation often necessitates interruption of the carotid arteries and their branches, frequently leading to changes in the cerebral circulation and consequently to mental and physical disabilities

Neurinoma A fairly common site for this innocent tumour to arise is in connection with one of the roots of the bronchial plexus. It presents as a solid or elastic swelling in the supraclavicular region and is often mistaken for a malignant lymph node. Its fusiform shape and the fact that pressure on it may give rise to parasthesiæ in the forearm or hand enables the diagnosis to be made. No treatment is necessary

Cervical Rib. This is described in Chapter 11 It may be palpated above the clavicle and be mistaken for a fixed mass of nodes.

Section Five

THE SURGERY OF SPECIAL SYSTEMS

SELWYN TAYLOR MICHAEL HARMER
T HOLMES SELLORS RAINSFORD MOWLEM
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Chapter 34

THE ENDOCRINE SYSTEM

Introduction

The endocrine glands comprise all those which produce internal secretions and in this chapter the thyroid parathyroids, thymus, adrenals and pancreas will be considered from their endocrine aspects. It is doubtful at the present time whether the thymus is in fact an organ of internal secretion but it is convenient to include it here. The pituitary gland produces many hormones, but on account of its anatomical situation the surgical affections concerning it are described in Chapter 24 which deals with the central nervous system Finally the ovaries and testes are important endocrine organs, but are more appropriately discussed in Chapters 53 and 52.

THE THYROID GLAND

From the surgeon s point of view the thyroid is by far the most important of all the internal secreting glands in the body It is shaped approximately like the letter H and lies in the neck, closely related to the larynx and trachea. There are two lateral lobes, joined by an isthmus which usually overlies the second third and often the fourth rings of the trachea A small pyramidal lobe may arise from the upper aspect of the isthmus and can be continuous with a thyroglossal tract which extends up towards the foramen cæcum at the back of the tongue. The blood supply of the gland is very generous and is derived from the two superior thyroid arteries which are branches of the external carotid and from the two inferior thyroid arteries which are derived from the thyrocervical axis. There is sometimes a fifth artery the thyroidima, which arises from the innominate artery or the arch of the aorta. It is a tiny artery and is distributed to the isthmus. The blood drains from the thyroid by veins which accompany both the superior and inferior vessels and also by large middle thyroid veins which pass laterally to enter the internal jugulars. The thyroid and the adrenal are probably the most vascular organs in the body

The thyroid gland is made up of a great number of follicles small, spherical structures formed of a single layer of cells covered externally by a rich network of blood vessels and containing within the lumen a sticky substance called colloid These follicles, which are the building blocks of the thyroid, are capable of manufacturing the thyroid hormones which they store within their lumena. The hormones are then mobilized as required and passed into the circulation. The main control of this storage and discharge is the thyroid stimulating hormone (TSH) of the anterior lobe of the pituitary and destruction of the pituitary thus leads to atrophy of the thyroid The main hormone of the thyroid gland is thyroxine, but there are other secretions such as triiodothyronine which, in certain circumstances, un-

fluence metabolism The main action of the thyroid hormones is to stimulate the metabolic rate of all the tissues in the body and absence of these hormones leads to slowing down of metabolic processes, a clinical condition called *myxœdema*.

Simple Goitre. The term goitre means an enlargement of the thyroid gland and simple goitre refers to that condition in which, due to an inadequate supply of iodine the gland becomes enlarged In order to manufacture the hormone thyroxine, the body requires a certain minimal supply of iodine in the diet, somewhere between 100 and 200 microgrammes a day

Ætiology In certain parts of the world especially in mountainous areas such as the Swiss Alps, Himalayas and Andes, the supply of iodine is in-

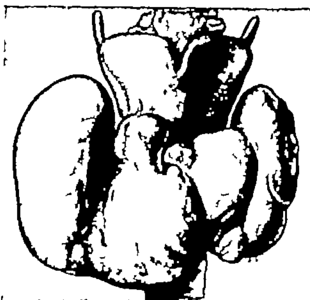


FIG 34 1 SIMPLE NODULAR GOITRE.

adequate and most of the population develop some enlargement of the thyroid. It is, therefore vitally important that an adequate intake of iodine be provided in the diet so as to prevent the enormous amount of disability which still occurs at the present time as a result of this preventable condition The best means of achieving this is by adding iodine to table salt. Many countries in fact now do this, for example Switzerland, New Zealand, Jugoslavia and Argentina and a fall in the incidence of goitre has followed. Conversely in countries where sea food (which has a generous iodine content) forms a considerable part of the diet, as for example in Japan and Iceland goitre is quite uncommon The total number of goitrous people in the world has been recently estimated at not far short of two hundred million.

The natural history of the development of simple goitre is probably as follows In the child, iodine intake being inadequate, the thyroid is unable to supply the hormone required by the body and this diminished level of thyroxine stimulates an increased output of thyrotrophic hormone (TSH) by the anterior pituitary which in turn leads to hyperplasia of the thyroid. This is most noticeable at puberty when demands made on the gland are at their greatest. As time goes by the thyroid in girls tends to enlarge while

that in boys frequently regresses in size this being related to the transient stimulation of the gland before menstruation and the more lasting stimulation during pregnancy

At the age of thirty nodules may begin to appear and these are frequently the site of hæmorrhage, which leads to their destruction and they are later replaced by cysts or masses of new tissue Eventually the gland is almost entirely replaced by a mass of nodules which may compress the trachea œsophagus and great vessels with accompanying dyspnœa and dysphagia Calcification is often observed in areas into which hæmorrhage has occurred Thyrotoxicosis and thyroid cancer occur more commonly in areas of endemic goitre than elsewhere



FIG. 34 A. INFRA-RED PHOTOGRAPH OF A LARGE SIMPLE GOITRE WITH RETRO-STERNAL EXTENSION IN A WOMAN AGED 68.
The enlargement of the subcutaneous venous plexus is well seen.

Treatment Most of the simple goitre in the world could be prevented by ensuring that there is a daily intake of 100 microgrammes or more of iodine and as already stated, the simplest way of doing this is by providing iodized salt. Where enlargement of the thyroid is seen at puberty treatment may be instituted by means of dried thyroid extract, 100 to 200 mg. per day or sodium l-thyroxine 0·2 to 0 3 mg. per day, or triiodothyronine 50 to 100 microgrammes (μg) per day Such treatment has to be continued for at least a year for an improvement to be noted. In addition, patients should be recommended to use iodized salt. When nodules appear in the thyroid gland no kind of treatment will remove them except a surgical operation, although aspiration will temporarily reduce the size of those containing fluid.

In recent years it has been possible by means of radioactive iodine and chromatographic studies, to distinguish a certain number of simple goitres as due to inborn errors of iodine metabolism which are usually familial in distribution These individuals are unable to manufacture thyroxine but

may be found to have precursors of the hormones, such as monoiodotyrosine or diiodotyrosine, circulating in the blood stream. These patients have large vascular goitres and may be cretinous.

A *cretin* is a dwarf in stature with typical puffy features and severely retarded mental and physical development. The association of cretinism with goitre is not clearly understood but cretins occur wherever goitre becomes severely endemic. Occasionally cretins occur in non-goitrous areas as described above.

Thyroiditis

The term thyroiditis implies inflammation of the thyroid gland but by long usage it has come to be used for a number of conditions in which infection or trauma appear to play no part It is convenient to differentiate acute from chronic thyroiditis, placing in the former category those examples due to bacterial infection, and in the latter group those diseases of the thyroid usually associated with the names of de Quervain Hashimoto and Riedel.

Acute Thyroiditis. This is a rare disease due to blood borne infection either by streptococcal, staphylococcal, gas-forming organisms, or the typhoid bacillus. Clinically there is usually a sudden onset of pain and swelling in the region of the gland and the patient has a fever and sometimes a rigor Dysphagia is marked and extension of the neck painful On examination there is a firm, smooth swelling in the neck which is usually very tender with the passage of time the overlying skin may become red and warm. The sedimentation rate is raised and there is a polymorphonuclear leucocytosis.

The condition is most readily confused with cellulitis of the neck but if the patient is asked to swallow it can be seen whether the inflamed thyroid moves. Swallowing may however be so painful as to make this examination difficult and often the patient finds it more comfortable to hold the chin down so as to relax the pretracheal muscles The most important complication is suppuration but this is rare If an abscess forms it must be drained surgically or it will burst through the skin or into the mediastinum. Rupture into the trachea has been reported

Treatment The treatment of acute thyroiditis is the same as that for acute infection occurring anywhere in the body The patient is kept in bed and given a fluid diet since this is easier to swallow The local application of an ice bag to the neck may be soothing, but some patients prefer local heat in the form of a kaolin poultice. Pus should be drained if it forms and antibiotics should be given when the type of organism is known Tracheotomy is rarely necessary since drainage of the abscess relieves the pressure on the trachea

Chronic Thyroiditis. *Hashimoto's Disease* This condition which was first described in 1912, is also called struma lymphomatosa or lymphadenoid goitre on account of the replacement of thyroid epithelium with lymphoid tissue The condition is seen almost exclusively in women and most frequently presents after forty years of age. There are no typical clinical signs or symptoms and the patient only complains of a swelling in the neck which may produce local pressure and occasionally dysphagia. Pain only rarely occurs. On examination the thyroid gland is usually moderately enlarged and may feel rubbery the most distinctive feature is that the edges are

much more easily defined than those of a simple goitre Enlarged lymph nodes may be palpated in the vicinity of the gland Hypothyroidism is produced by this condition and usually progresses to myxœdema if left untreated

The cause of Hashimoto s disease is sensitization of the patient to her own thyroglobulin this auto-immunization leading to the production of antibodies and a progressive destruction of the thyroid gland with infiltration and replacement with lymphocytes and lymphoid tissue One of the earliest changes in thyroid function accompanying this disease is defective organic binding of iodine. This can be demonstrated by giving the patient a tracer dose of radioactive iodine followed by potassium perchlorate when almost all the radioiodine is discharaged from the gland Other changes occur with this immune reaction and make it possible to diagnose the condition without having to remove thyroid tissue There is a rise in the circulating gamma globulin a grossly abnormal colloidal gold test is obtained with the serum and liver function tests are abnormal Biopsy of the thyroid gland either by removing a small portion at open operation or by needle biopsy may be done to confirm the diagnosis.

Treatment of Hashimoto s thyroiditis consists of giving the patient ade quate doses of thyroid by mouth, continuing it for life. The result is a diminution in the size of the thyroid and signs of hypothyroidism disappear since the level of thyroxine is now restored Surgery has no place in the treatment of this disease except when there are severe pressure symptoms.

De Quervain s Thyroiditis This condition, which was first described in 1904 is known by a multitude of names since it has been rediscovered by other workers from time to time ever since. Some of the commoner names are subacute thyroiditis, granulomatous thyroiditis, pseudo-tuberculous thyroiditis and struma granulomatosa. The condition is not common and approximately one example is seen for every ten of Hashimoto s disease. Epidemics have been reported and it has been suggested that the mumps virus is a cause of the condition Typically the onset is acute, the patient complaining of a sore throat, malaise fever and a tender painful thyroid gland. There may be night sweats, weakness and lassitude. The thyroid gland is a little enlarged and on palpation feels firmer than usual. The condition may occur in a thyroid which is already enlarged as a result of simple goitre. Laboratory investigations reveal that the white cell count is normal, but the sedimentation rate is grossly elevated and when a tracer dose of radioactive iodine is given there is no uptake by the thyroid gland. Since this is the only condition in which these findings are obtained the diagnosis can be made precisely

The disease progresses to spontaneous resolution in three months to a year Needle biopsy can be used to confirm the diagnosis since the histological picture is fairly distinctive. Most patients require no specific treat ment for this condition other than reassurance. When the symptoms are severe, improvement can be obtained by giving small doses of cortisone or of an antithyroid drug.

Riedel's Thyroiditis This is a very rare condition and unlike most thyroid diseases does not show the usual preponderance of women over men. Clinically the condition presents as a chronic induration of one lobe of the thyroid which eventually becomes stony hard and completely adherent to the surrounding tissues. The disease progresses painlessly involving the

opposite lobe and eventually leads to obstruction of the trachea there may even be involvement of the recurrent laryngeal nerves and destruction of the parathyroid glands An unusual feature is that thyroid function is rarely interfered with and myxœdema does not occur although the gland is largely replaced by fibrous tissue

The treatment of Riedel s disease is relief of obstruction to the trachea and other structures in the neck. It is impossible to perform thyroidectomy owing to the adhesions surrounding the gland and therefore division of the isthmus is usually all that can be done

Toxic Goitre

Hyperthyroidism Thyrotoxicosis. The ætiology of toxic goitre is not known, but there is often a history of some kind of mental shock or trauma preceding the onset of the disease which suggests that in some patients this may be considered to be a psychosomatic condition Often more than one member of a family develops the disease suggesting that a certain type of individual is more prone to it. Occasionally a patient who has been following a strict régime of dieting continues to lose weight after returning to a normal diet and is then found to be suffering from hyperthyroidism.

Parry of Bath gave the first accurate account of the condition in 1825 but Graves of Dublin added so much to our knowledge ten years later that his name is often given to the condition In most European countries toxic goitre is called von Basedow's disease after the German physician who described it a few years after Graves.

Varieties of Toxic Goitre It is convenient to distinguish two varieties of toxic goitre although it must be remembered that every gradation may be seen between these On the one hand there is the young patient who has a smooth uniform enlargement of the thyroid a fast pulse rate increased metabolic rate and sweating palms voracious appetite and often rather loose motions There is usually pronounced nervousness and intolerance of hot weather The eyes are prominent, which is referred to as exophthalmos, a rim of white sclera being visible both above and below the pupil. The title Graves s disease has been applied to this particular form of thyrotoxicosis.

On the other hand a patient in an older age group in whom an enlarged thyroid gland has been present for some years, may develop hyper thyroidism which presents in a rather different form. The brunt of the disease falls on the cardiovascular system so that there is tachycardia followed by auricular fibrillation and finally congestive heart failure The other signs of the disease such as exophthalmos and sweating are much less marked or even absent. A suitable title for this condition is toxic nodular goitre it is unwise to call it secondary hyperthyroidism, as is often done when the primary cause is still not known These two forms of hyper thyroidism will be considered separately here but it is again stressed that many intermediate examples may be seen

Graves s Disease. This condition is much more commonly seen in women than men The onset may be acute with diarrhœa high temperature sweating and fast pulse rate, or it may be insidious with loss of weight increased nervousness and irritability

Physical Signs On examination the patient appears apprehensive and nervous and the most striking feature is the exophthalmos (Fig. 34 3). In addition to the prominence of the eyes the lids are retracted and there is

usually a stare The myopathy and muscle weakness which accompany the condition lead to lid lag, which can best be demonstrated by asking the patient to follow the examiner's finger as it is moved up and down the upper eyelid is then seen to lag behind the movement of the eyeball

The thyroid gland is usually moderately enlarged to about twice normal size, is smooth and vascular the latter condition often leading to a palpable thrill and audible bruit over the gland The palms are usually moist and there is a great tendency to perspiration the appetite is voracious and the bowels are loose The cardiovascular system is affected both centrally and peripherally There is an increased pulse rate the systolic pressure may be



FIG. 34 3 GRAVES'S DISEASE.
Note exophthalmos.

a little raised but the diastolic pressure is usually considerably lower than normal, so that there is a large pulse pressure which is readily palpable at the wrist. Longstanding hyperthyroidism may lead to auricular fibrillation but this is more usual in toxic nodular goitre Not only is there nervousness, but there is increased excitability of the whole nervous system so that reflexes are brisk and readily elicited There may be coarsening of the hair which tends to fall out There is always some degree of muscle weakness which may be most marked when the patient tries to go up stairs. The muscle wasting is accompanied by the excretion of creatine in the urine

There are now many different methods of treating thyrotoxicosis, the three most important being the use of antithyroid drugs, surgical removal of the gland and radioactive iodine. These will be considered in turn and the various indications for their use mentioned.

The Antithyroid Drugs The history of the antithyroid drugs starts in 1928 when it was discovered that rabbits fed on a diet of cabbage developed

goitre. Subsequently it was found that the sulphonamides were also goitrogenic and, by an investigation of a large number of compounds related chemically to these, Astwood discovered that thiourea was an extremely active thyroid blocking agent. Since 1943 thiouracil in its methyl and propyl forms has been widely used for treating Graves's disease. It works by preventing synthesis of thyroxine in the gland thus by giving a patient between 200 and 600 mg. of the drug daily (divided in three or four doses) it is possible to control the disease in a few weeks rendering the patient euthyroid (*i.e* of normal thyroid function). The drawback of thiouracil therapy is the toxic reactions which it may produce *e.g* skin rashes, joint pains and, most importantly of all, depression of the polymorphonuclear leucocytes and the production of agranulocytosis. In this condition the patient develops a sore throat, high temperature and is very ill if not treated at once by the administration of massive doses of penicillin together with transfusion of fresh blood, death may occur Methyl or propyl thiouracil can be continued in small doses by mouth for weeks, months or years in suitable patients thus controlling the disease. If after a year the drug is stopped, the likelihood of a remission in the thyrotoxicosis appears to be not more than about 30 per cent. For this reason long term thiouracil therapy is reserved for those patients who are unsuitable, either physically or mentally for surgical operation and for those patients who are young and in whom there appears to be a greater likelihood of a remission. The drug is unsuitable for use in patients who are sensitive to it or in those who are averse to taking medicine over a long period

The use of an antithyroid drug can be very conveniently combined with thyroidectomy since the patient is rendered safe for operation Thus the most acceptable way of treating hyperthyroidism at the present time, when the patient is severely toxic, is the administration of an antithyroid drug for from one to three months, followed by subtotal thyroidectomy The antithyroid drugs lead to increased size and vascularity of the thyroid gland in some patients. This is because, when the secretion of thyroxine is lowered there is increased secretion of thyroid stimulating hormone or TSH by the pituitary This can be prevented by giving smaller doses of the antithyroid drug or by administering with the antithyroid drug, small doses of thyroxine to suppress TSH secretion

Many new antithyroid drugs have been evolved since the introduction of thiouracil. At the present time carbimazole appears to be the least toxic of all these and the most suitable for general clinical use It is about ten times more potent weight for weight than the methyl thiouracil originally used in this country or the propyl thiouracil which was in vogue in other parts of the world Carbimazole in doses of 10 mg. three times a day will control most patients with hyperthyroidism Dosage can often be reduced to half this level after a month and some surgeons believe that there is less enlargement and vascularity of the thyroid than with the thiouracils.

Thyroidectomy Until recently thyroidectomy was the best treatment for hyperthyroidism and still remains an extremely useful one In the early days it was found that operating on the toxic patient often led to a thyroid crisis in which the patient's pulse rate became extremely rapid, there was hyperpyrexia, great sweating, air hunger heart failure and sometimes death. This complication not only followed operations on the toxic thyroid itself but any kind of surgical intervention in a patient with hyperthyroidism.

For this reason surgical treatment of the disease was regarded askance for many years In the early 1920's Plummer introduced preparation of the toxic thyroid patient for surgery by means of iodine Lugol's iodine (5 per cent iodine in 10 per cent. watery solution of potassium iodide) was given as five to fifteen drops three times a day for ten to twenty days and following

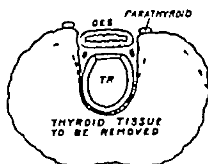


FIG 34 4 THE AMOUNT OF THYROID REMOVED IN SUBTOTAL THYROIDECTOMY

this the patient felt better the pulse rate settled there was some increase in weight and the thyroid gland became much firmer and less vascular When these improvements were maximal a subtotal thyroidectomy was carried out which usually led to a permanent remission of the disease If the operation was radical the recurrence rate was only about 5 per cent.

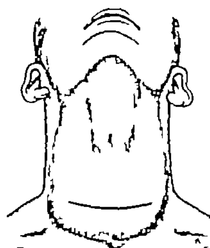


FIG 34 5 POSITION AND SIZE OF COLLAR INCISION.

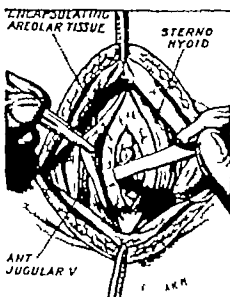


FIG 34 6. EXPOSURE OF THYROID GLAND
The infrahyoid muscles have been retracted and the capsule of the gland incised.

Subtotal thyroidectomy is performed as follows. The patient is given a general anæsthetic and an intratracheal tube introduced. Occasionally the operation is performed under local analgesia. It is necessary to have a firm support under the shoulders in order that the neck is well extended A collar incision is made, following where possible one of the natural creases, and

flaps are raised including the platysma muscle. The strap-muscles, the sternohyoid and sternothyroid, are separated in the midline to expose the gland (Fig. 34 7) and if the latter is large the muscles are divided transversely in their upper part to give better access. The superior thyroid vessels are doubly ligated and divided. The inferior thyroid artery is defined and ligated in continuity as far away from the gland as possible to avoid damage to the recurrent laryngeal nerve The nerve is sought for and having been found is carefully preserved from injury during the rest of the operation The middle thyroid veins are tied and cut and also the vessels at the lower poles. The gland is then delivered into the wound, the isthmus divided and about seven-eighths of each lobe removed small pads of thyroid tissue

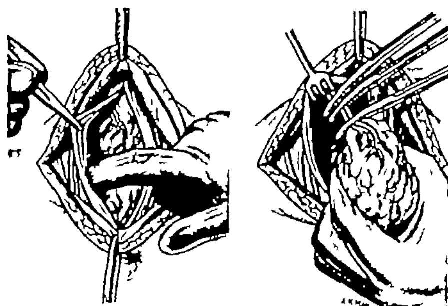


FIG 34 7 METHOD OF DELIVERING THE UPPER POLE OF THE THYROID GLAND AND LIGATURE OF THE SUPERIOR THYROID VESSELS.

being left, which protect the recurrent nerves. Hæmostasis is obtained the wound drained with fine rubber tubes, the muscles sewn with catgut and the skin closed with Michel s clips.

The complications of partial thyroidectomy are those which may follow any surgical operation, but in addition the following are peculiar to thyroidectomy There may be hæmorrhage in the first twenty four hours and if the accumulated blood clot presses on the trachea this may lead to severe dyspnœa and even death if not relieved Relief is readily afforded by removing the sutures and allowing the blood clot to be extruded It is unusual to find a main bleeding point which requires ligature and the blood usually comes from a great number of oozing points. If the patient has not been adequately prepared and is still toxic at the time of operation, there may be a thyroid crisis. Such a patient should be nursed sitting up sponged with tepid water and if necessary have oxygen administered by means of a mask Intravenous sodium iodide solution is reputed to be of help and cortisone has also been employed to tide these patients over the crisis.

If one of the recurrent nerves is damaged at operation there will be loss of abduction of one vocal cord with hoarseness, occasionally some

difficulty in swallowing and inability to shout It is remarkable how with the passage of two or three months the voice usually returns almost to normal as the opposite vocal cord adjusts itself to the new conditions If both recurrent nerves are damaged then the vocal cords lie adducted near the midline and the patient has great difficulty in phonation and has dyspnœa on exercise This tragic condition can be corrected by an operation designed to swing one of the vocal cords away from the midline by moving the arytenoid cartilage. A further complication will arise if all the para thyroid glands are excised since the patient then lacks parathormone and there is tetany This does not usually appear until three or four days after operation when the patient first complains of tingling in the hands or feet and later cramps in the legs. The diagnosis is confirmed by finding a serum calcium level below 10 mg per cent. and immediate treatment should be an intravenous injection of 20 ml of 20 per cent. calcium gluconate which relieves the symptoms. Subsequently the patient is given large doses of calcium gluconate or lactate by mouth and in some patients this suffices Where the condition is more severe however calciferol may be given daily and the most resistant cases usually respond to A T 10 (dihydrotachysterol) by mouth which with calcium by mouth maintains an adequate serum level of calcium.

Radioactive Iodine Since the thyroid gland concentrates iodine, it will also concentrate radioactive isotopes of this element and thus it is possible to irradiate the gland from within and destroy it in part or *in toto* The isotope commonly used is I^{131} which has a half life of eight days. It emits beta and gamma rays, the former providing most of the ionizing radiation which will destroy the gland Since the beta rays have a penetration in tissue of only a few millimetres, no surrounding structure is damaged. The gamma rays can be detected outside the body and are useful for measuring the amount of the isotope retained in the thyroid and for determining how long it is retained there. Since the amount of radiation delivered to the gland by this technique is of a high order there is the risk that with the passage of time a malignant change might be induced For this reason patients under the age of forty five are not usually treated with radioactive iodine but it should be added that although the isotope has been used for therapy in ever increasing amounts since about 1943 no patient has yet been recorded who has developed a malignant change in the gland as a result of its use. Patients have, however developed leukæmia following therapy with the isotope

The type of patient for this form of treatment is therefore one past middle age who is unsuitable for operation possibly for reasons of temperament or because of severe heart disease, or any other condition which makes a general anæsthetic unsafe. Those patients who have recurrent hyperthyroid ism following a previous operation especially when they have suffered damage to a recurrent laryngeal nerve, are particularly suited to this form of therapy

In practice a tracer dose of about 10 microcuries (μc) is given by mouth and the amount of the isotope retained in the gland is measured A rough estimate as to the size of the gland is then determined by palpating the neck and the fasting patient is given a dose of radioiodine of approximately 150 μc per estimated gramme of tissue. The tracer dose will have shown what percentage of this is retained by the thyroid The improvement in the patient is gradual and is not complete until about three months have elapsed The disadvantages of the treatment are that it is difficult to calculate the

correct dose and a higher incidence of myxœdema follows its use than any of the other forms of therapy used for thyrotoxicosis.

Hyperthyroidism in Children. When this occurs it is invariably accompanied by exophthalmos and marked constitutional changes. The ideal form of treatment is control of the disease by an antithyroid drug such as carbimazole. It has been found that potassium chlorate which acts as a mild blocking agent on the thyroid can be given in large doses (200 mg. three times a day) without toxic effects and is ideal for the long-term therapy necessary in these young patients. Often at puberty treatment can be discontinued and a remission expected. It is desirable not to perform thyroidectomy in the young if it can be avoided although the operation has been performed with satisfactory results. Radioactive iodine should on no account be used in young patients with hyperthyroidism

Toxic Nodular Goitre. Patients with this condition fall into an older age group and the thyrotoxicosis, which is often insidious in onset primarily affects the cardiovascular system. Exophthalmos is usually absent. The patient may appear with long standing disease, with auricular fibrillation or in heart failure Treatment for toxic nodular goitre should always be surgical *since it is found that this best relieves the strain on the heart and no other* form of therapy offers such good results. The patient should be prepared for surgery by means of an antithyroid drug, such as carbimazole, but this is not so effective as in Graves s disease and may need to be given for many months before the patient can be considered fit for operation. Subtotal thyroidectomy is performed leaving a minimum of tissue, as it is almost unknown for these patients to develop myxœdema subsequently The improvement in the cardiovascular state is great and therefore even the most severely debilitated patients are well worth treating. These patients are in a suitable age group for the use of radioactive iodine, but it is usually found that they require far greater doses than the weight of the gland would suggest. Subtotal thyroidectomy has been found a more suitable form of treatment.

Malignant Goitre

Carcinoma of the thyroid has a geographical distribution, being more commonly seen in countries where goitre is endemic. It is only twice as common in women as men, a much lower sex ratio than is seen in most other thyroid diseases. Up to the age of forty cancer is equally common in men and women and it is only over this age that it becomes relatively more frequent in the female. Children who have had irradiation to the neck or mediastinum are particularly liable to develop thyroid cancer although irradiation of the neck after puberty does not appear to carry the same risk.

In order to discuss carcinoma of the thyroid it is first necessary to describe the various pathological varieties of tumour which occur They are the papillary follicular and anaplastic. It should be remembered that thyroid cancer is a relatively rare condition in England and Wales and only a little over 300 deaths are reported each year as a result of it.

Papillary Carcinoma. This is typically a disease of young adults and those rare examples of cancer of the thyroid in childhood belong to this pathological type. *The tumour is usually slow growing* and tends to spread by the lymphatics. A solitary nodule in a young patient, especially when there are palpable firm lymph nodes in the neck should raise the suspicion of malignancy The tumour may be well differentiated and the metastases

only grow extremely slowly This explains the cases of so-called lateral aberrant thyroid which were previously considered to be due to abnormalities of embryonic development They are in fact the secondary deposits of well differentiated carcinoma in cervical lymph nodes.

Treatment Because the disease is so slow growing, a conservative approach has been recommended for its treatment Thus if the tumour is confined to one lobe of the thyroid hemithyroidectomy accompanied by removal of any affected lymph nodes on that side of the neck may lead to an apparent cure When the disease is more aggressive and a number of lymph nodes is found to be involved it is necessary to combine total thyroidectomy with a block dissection on one or both sides of the neck Considerable dependence must be put on the histological evaluation of the tumour Whether conservative or radical surgical extirpation is employed it is essential to combine it with adequate thyroid replacement therapy Indeed



FIG 34 8 THYROID CARCINOMA, FOLLICULAR TYPE.

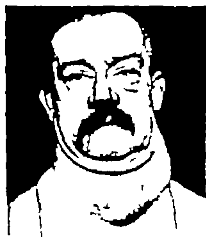


FIG 34 9 ADVANCED THYROID CARCINOMA, ANAPLASTIC TYPE.

the dose of thyroid given by mouth should be more than that necessary to replace the tissue removed as there is evidence to suggest that suppressing production of TSH by the pituitary may inhibit the thyroid and prevent further growth of any remaining malignant tissue.

Follicular Carcinoma. This variety of thyroid cancer may occur at any age, but is typically seen between forty and sixty years. The tumour is usually easily palpated and is encapsulated. It may be present for very many years before metastases occur and these metastases spread by the blood stream, typically to bone and lung. When the metastases are well differentiated they may be indistinguishable from normal thyroid tissue and can then elaborate thyroxine. It is this property which renders them capable of treatment by radioactive iodine.

Treatment When follicular carcinoma of the thyroid has been diagnosed a total thyroidectomy should be performed since this not only removes the primary growth but also the normal thyroid tissue and leaves the patient dependent on the metastases for further hormone production If the metastases are well enough differentiated to produce hormone they will be stimulated to do so by the thyroid stimulating hormone (TSH) of the anterior

pituitary Thus, if the patient is left after total thyroidectomy for three months, myxœdema usually occurs and the secondaries may then be capable of taking up radioactive iodine. If this is the case a large dose between 100 and 200 millicuries of I^{131} is given and if concentrated in the secondary deposits may shrink them considerably and lead to relief of symptoms. When the secondary deposits from the carcinoma do not take up iodine they may be stimulated to do so following thyroidectomy by the administration of TSH by injection, five to ten units daily for five days, or by giving large doses of an antithyroid drug such as carbimazole for two to three months. The taking up of radioiodine by the metastases is determined following a tracer dose by holding a Geiger Müller or scintillation counter over the secondaries to see if the isotope has been concentrated in them

Follicular carcinomas which are less well differentiated are treated by radiotherapy in the conventional way, combined with the giving of full replacement doses of thyroid by mouth. Dunhill was the first to report that multiple metastases in the lungs sometimes disappeared after giving adequate doses of thyroid by mouth.

Anaplastic Carcinoma. Unfortunately this group of very malignant tumours comprises nearly half of all thyroid neoplasms. From a pathological point of view anaplastic carcinoma can be split into two groups the small cell and the giant cell. The first of these, often called *carcinoma simplex*, shows a remarkably uniform picture under the microscope in most cases although, when some differentiation occurs, occasional outlines of follicles appear In the giant cell carcinoma there is great pleomorphism with occasional large cells of irregular size and nuclear shape. Anaplastic carcinoma occurs much more commonly in women than men, usually in those over the age of sixty and is unresponsive to most methods of therapy It causes a rapidly enlarging smooth swelling of the thyroid gland and the spread is both by local extension and distally by lymphatics and the blood stream

Treatment Surgical excision offers little hope of removing the tumour and is often attended by unpleasant complications, tracheostomy being frequently necessary The tumour is, however radiosensitive and high voltage X-ray therapy offers good palliative treatment for this variety of thyroid tumour The diagnosis is best made by needle or drill biopsy since open operation may lead to fungation of the tumour in the wound. Prognosis is poor and the survival with small cell tumours is of the order of three years, whereas with giant cell tumours it is almost always less than one year

It is most unusual for malignant change to occur in a toxic patient and in the presence of thyrotoxicosis it can usually be assumed that any swelling *in the thyroid is not malignant.*

Rare Thyroid Tumours. There are a few other types of interesting neoplasms which occur rarely in the thyroid gland. Squamous carcinoma may occur and is difficult to account for but this type of metaplasia is also seen in other tissues. Another tumour arises as a small, sclerosing, non encapsulated hard nodule. It is hard and white on section and is occasionally seen in a toxic thyroid Such tumours do not spread Reticulosarcoma is a rare finding but may complicate Hashimoto s disease.

THE PARATHYROID GLANDS

The parathyroid glands were discovered in 1880 by the Swedish anatomist Sandström. They are four small yellowish brown bodies which lie usually on the posterior aspect of the thyroid often associated with branches of the main arteries where they enter the gland substance They are difficult to recognize at operation or in the post mortem room and may be found in situations far away from the thyroid owing to aberrations in their development. They have been described as occurring as low down in the mediastinum as the arch of the aorta and posteriorly behind the œsophagus. The main interest of these glands to the surgeon is that they may be the seat of hyper functioning adenomata or of generalized hyperplasia either of which may produce profound changes in the body s calcium metabolism which they normally control Likewise they may be excised during thyroidectomy and the patient s serum calcium then falls and tetany results.

Hyperparathyroidism. This is a rare disease which is only diagnosed by the symptoms it produces and not by the finding of a swelling in the neck With increased secretion of parathormone the patient usually feels tired and weak, there is often aching in the lower limbs and back and usually some mental irritability Decalcification of the skeleton takes place owing to the mobilization of calcium in order to maintain a high serum calcium level. This decalcification leads to osteoporosis and collapse of vertebræ bowing or fracture of the femora and the presence of cystic tumours in bones, which may occur in any part of the body When involving the lower jaw these are referred to as epulides. The syndrome is usually called after von Recklinghausen The high level of secretion of calcium in the urine may lead to calcification in the renal tubules, streaks being seen in the kidneys on a skiagram. This leads to severe renal damage, raised blood urea or non-protein nitrogen levels and uræmia

In addition to the clinical findings of backache deformity bone cysts and renal damage there may be an intractable dyspepsia with ulceration of the duodenum which does not respond to any of the usual measures. Calcium may be deposited in many tissues in the body and may be recog nized in the eye as a band keratitis.

The diagnosis is confirmed by repeated estimations of the serum calcium which should be over 10 5 mg. per cent., the serum phosphorus which should be below 3 5 mg. per cent. and usually a raised serum alkaline phosphatase.

Treatment The treatment of hyperparathyroidism depends first of all on its recognition and then the removal of the parathyroid which contains the adenoma or if there is hyperplasia of all four parathyroid glands (as occurs in about 12 per cent.) removal of three of these and a large portion of the fourth. The operation is difficult since these tumours are hard to find and great pains must be taken in searching the likely sites where they may lie. In the post-operative period the patient may suffer severely from the acute lowering of the serum calcium and has tetany pain in the muscles and sometimes mental changes. Immediate relief may be given by the injection of 20 ml. of 20 per cent. calcium gluconate and this is followed by large doses of calcium by mouth and, if the symptoms persist, calciferol. The latter however prevents the "greedy" bones from obtaining the calcium they need and therefore delays recalcification of the skeleton which in any case, may take up to a year to occur

Hypoparathyroidism. This condition may occur as one of the complications of thyroidectomy When hypoparathyroidism is not severe or is overlooked there may be late complications due to the disordered calcium metabolism Cataract is one of these The treatment is to increase the daily intake of calcium giving vitamin D or calciferol in large amounts and, in intractable cases A.T 10 (dihydrotachysterol) by mouth.

THE ADRENAL GLANDS

The adrenal or suprarenal glands, which surmount the two kidneys are remarkable for the number of internal secretions which they produce The two glands together weigh between 6 and 10 g. and are extremely vascular receiving blood from at least three arteries. Venous drainage is by a stout vein from the hilum of each gland into the inferior vena cava on the right and the renal vein on the left.

Physiology So complex are the functions of the adrenal glands that it is first necessary to consider their physiology Each adrenal consists of an outer golden yellow cortex which is derived from the cœlomic epithelium and an inner reddish brown medulla derived from those chromaffin cells which give rise to the sympathetic ganglia.

The Cortex This is essential to life and produces a group of hormones about which much has been discovered in recent years. More than thirty

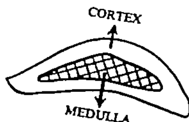


FIG. 34 10. ADRENAL DISORDERS.

of these hormones have so far been isolated however the functions of many of them overlap The raw material from which they are elaborated is cholesterol and they are usually identified by the number of carbon atoms in the molecule the two main precursors being the C.19 and C.21 steroids. There are three groups of steroids of physiological importance the glucocorticoids the androgens and the mineralocorticoids. *Glucocorticoids* regulate carbohydrate metabolism by increasing liver glycogen storage and control potassium and water balance In their absence the body is unduly sensitive to trauma and shock *Androgens* resemble those from the testis, they are secreted in both sexes and in addition to their virilizing effect encourage the laying down of protein *Mineralocorticoids* primarily control sodium and chloride retention in the body

The Medulla This is made up of two types of cell differentiated by their staining reactions with chromic acid Those which do not take up this substance are more differentiated nerve elements and give rise to tumours such as the *neuroblastoma* and *ganglioneuroma* Those staining with chromic acid the phæochromocytes may also give rise to tumours These are called *phæochromocytomata* and secrete two hormones adrenaline and nor adrenaline otherwise known as epinephrine and norepinephrine In the accompanying diagram some of the more important disorders due to abnor malities of these secretions are indicated.

Disorders of the Cortex

Cushing s Syndrome. This clinical picture was originally described by Cushing, but his view that it was always due to a basophil pituitary tumour is not now accepted, the primary cause being hypersecretion of certain elements of the adrenal cortex. There is, however a constant pituitary abnormality in these patients which is hyalinization of the basophil cells, usually called Crookes s cells. A pituitary tumour is occasionally present

Clinical Features Cushing s syndrome is commoner in women than men, is usually seen in young adults and rarely in children. Its main features are as follows great obesity especially of the abdomen, in the skin of which striæ develop as broad purple atrophic lines. The face becomes rounded and moon-like and a fat pad developing over the cervicothoracic spine gives a " buffalo " hump The limbs are not affected by the obesity but it is notable that the skin is thin the complexion ruddy with a great tendency to acne and an increased susceptibility to bruising. In addition there is marked muscular weakness, diabetes, which is usually mild but resistant to insulin, osteoporosis, especially of the vertebræ which may lead to collapse amenorrhœa, or impotence hypertension and degenerative arterial disease with headaches and polycythæmia and mental depression and personality changes, often associated with paranoia.

It should be remembered that in most patients not all these symptoms will be found, but a combination of some of them and the resulting clinical picture is usually a striking one. The diagnosis is confirmed by finding an increased level of glucocorticoids in the urine or serum. The condition is commonly associated with hyperplasia of the two adrenal cortices, but in about 10 per cent. of patients a cortical adenoma occurs as a circumscribed tumour This tumour may be demonstrated by skiagrams after presacral or perirenal air insufflation

Treatment The treatment of Cushing s syndrome is the removal of an

adrenal tumour when one is present and total bilateral adrenalectomy in the remainder of these patients. This necessitates giving cortisone before operation and it will have to be continued for the rest of the patient's life. Good results follow this operation, many of the patients returning to normal

Adrenogenital Syndrome. This condition is much more common in females than males, is congenital and often familial The cause is an inborn error of steroid metabolism in which the adrenal is incapable of synthesizing C.21 steroids which have metabolic activity Since a normal level of these hormones in the blood is apparently necessary to damp down pituitary secretion of adrenocorticotrophin (ACTH), there is excess secretion of the latter and bilateral adrenal hyperplasia. Occasionally a tumour of the adrenal cortex may produce an excess of androgens and lead to a similar appearance of virilization.

Clinical Features The picture presented depends upon the age at which adrenal hypersecretion starts to take effect. If it occurs during fœtal life a female child is born with a large clitoris and may be mistaken for a male child with undescended testes, *i.e.* a *pseudohermaphrodite* These babies suffer from a deficiency of normal adrenocortical hormones and may die as a result of vomiting, dehydration and collapse a condition resembling an Addisonian crisis in an adult. If hypersecretion occurs before puberty virilization occurs in girls and sexual precocity in boys There is greatly increased muscular development, hirsutism, deep voice and adult sex organs in the male with early fusion of the epiphyses of the long bones. The appearance is that of the so-called infant Hercules. When the changes occur in an adult woman there is amenorrhœa, partial baldness, the appearance of a beard and a change to the masculine type of build with prominent muscles. A rare variant of this condition is a feminizing change in the male

The diagnosis is confirmed by finding an increased level of 17 ketosteroids in the urine In those patients in whom a tumour is present, air studies may reveal it in skiagrams.

Treatment This consists in removing a tumour if one is present though such is rarely the case. Bilateral hyperplasia of the adrenals is more common and then administration of cortisone by mouth replaces the absent glucocorticoids suppresses excess secretion of ACTH by the pituitary and thus halts the virilizing process and returns the patient to normal Infants require 12 5 to 25 mg. daily by mouth or an intramuscular injection of 25 mg. on alternate days. Adults need 25 to 75 mg. daily The fall in 17 ketosteroid excretion, and reduction of hypertension when present, are guides to adequate replacement therapy which must be continued indefinitely

Primary Aldosteronism. The diagnosis of primary aldosteronism is difficult, for excessive retention of sodium and loss of potassium may not present a very distinctive clinical picture. The patient usually complains of weakness and tiredness and is often diagnosed as suffering from nephritis (another condition which may lead to depletion of the body's potassium) alternatively some form of myopathy may be suspected However where laboratory facilities are available to demonstrate an increased blood level of aldosterone, the diagnosis can be made. A few patients have had an aldosterone-secreting tumour removed from the adrenal cortex with complete cure of the symptoms In primary aldosteronism the cause is usually a tumour and not adrenal hyperplasia whereas in Cushing's syndrome hyperplasia is much more common than tumour

Disorders of the Medulla

Phaeochromocytoma This tumour occurs typically in young adults of either sex and it is commoner on the right side About 10 per cent. of tumours are bilateral and since chromaffin tissue may be found beside the abdominal aorta or in the mediastinum or neck tumours have also been found in these sites This type of tumour is rarely malignant and some produce no internal secretion

Signs and Symptoms The main manifestations of a phæochromocytoma are paroxysmal attacks of hypertension when the systolic blood pressure may rise as high as 300 mm of mercury Such an attack may be brought on by pressure on the loin exercise, or for no apparent reason The patient suddenly goes pale sweats and complains of a violent pulsating headache unconsciousness may follow Liver glycogen is mobilized during an attack, the blood sugar raised and also the basal metabolic rate for this reason the condition may be mistaken for hyperthyroidism. The hypertension may be paroxysmal or sustained

These tumours secrete adrenaline (epinephrine) and noradrenaline (nor epinephrine) in varying amounts The adrenaline may cause a rise in blood pressure due to increased cardiac output on the other hand noradrenaline acts as a vasoconstrictor and is responsible for most of the rise in blood pressure and hence most of the symptoms

Many tests have been devised to help in the diagnosis of this condition. The most valuable is the estimation of noradrenaline in serum and urine, but this requires a very complicated technique which can only be carried out in a few laboratories. Various adrenolytic drugs have been used diagnostically notably dibenamine, piperoxane hydrochloride and phentolamine hydrochloride, but when they do not lower the blood pressure it does not necessarily exclude the presence of a phæochromocytoma. The injection of histamine to provoke an attack is not without danger and therefore should not be used

Treatment The treatment of phæochromocytoma is surgical excision of the tumour or tumours and this has to be carried out with the greatest gentleness. *Manipulation of the tumour discharges noradrenaline into the* blood stream and can lead to extremely severe hypertension which may be fatal. Successful extirpation of such a tumour may be followed by profound hypotension which needs controlling with an intravenous infusion of nor adrenaline. Eventually the cardiovascular system adapts itself to the reduced level of circulating noradrenaline.

Bilateral Adrenalectomy in Malignant Disease

This operation is mentioned in Chapters 7 and 35 Bilateral removal of the adrenals, as first introduced by Huggins, has a place in the treatment of widely disseminated malignant disease, especially in carcinoma of the breast and prostate The reason is that it probably reduces the level of circulating œstrogens, but it may also be related to removal of certain adrenal corticoids. It is important that the patient be properly prepared for operation and 50 mg. of cortisone acetate should be given intramuscularly twice daily for three days prior to operation. This dosage must be continued on the day of operation and for four or five days thereafter A supply of intravenous hydrocortisone should be available in case of emergency both in the

adrenal tumour when one is present and total bilateral adrenalectomy in the remainder of these patients. This necessitates giving cortisone before operation and it will have to be continued for the rest of the patient's life. Good results follow this operation many of the patients returning to normal.

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Treatment. This consists in removing a tumour if one is present, though such is rarely the case. Bilateral hyperplasia of the adrenals is more common and then administration of cortisone by mouth replaces the absent glucocorticoids, suppresses excess secretion of ACTH by the pituitary and thus halts the virilizing process and returns the patient to normal. Infants require 12.5 to 25 mg. daily by mouth or an intramuscular injection of 25 mg. on alternate days. Adults need 25 to 75 mg. daily. The fall in 17-ketosteroid excretion and reduction of hypertension when present, are guides to adequate replacement therapy which must be continued indefinitely.

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operating theatre and in the ward post-operatively Following operation, cortisone can more conveniently be given by mouth the dosage varying in different individuals from 25 to 75 mg. daily Oral cortisone is more rapidly absorbed into the blood stream than by the intramuscular route but the latter is used over the operative period in case of vomiting

Technique The operation of adrenalectomy can be performed by a variety of different routes If each adrenal is to be removed separately then an approach *via* the ordinary kidney incision in the loin is suitable When it is desired that both adrenals should be removed at the same operation two alternative methods are available In a thin patient a transabdominal approach is satisfactory whereas in the obese subject, such as one suffering from Cushing's syndrome it is better for the patient to lie face-down in the jack knife position Bilateral incisions are then made through the bed of the eleventh rib on each side In children the transabdominal route is always the most satisfactory as access is good and the adrenal glands in children are relatively larger than in adults.

THE PANCREAS

Islet-cell Tumours. An adenoma which secretes insulin may arise in the pancreas and is often referred to as a nesidioblastoma It is a rare condition and the tumour is multiple in about 10 per cent of cases A malignant variety of insulin secreting tumour is excessively rare.

Signs and Symptoms The clinical picture presented by an islet-cell tumour is often referred to as Whipple's triad. It consists of an attack of prostration or gastro-intestinal upset occurring when the patient fasts associated with a blood sugar level of less than 50 mg. per cent. the attack being immediately relieved by the ingestion or injection of glucose. These patients are often obese because they have found their symptoms are relieved by taking food The onset of a hypoglycaemic attack may be heralded by the patient becoming pale, the muscles then twitch and a period of unconsciousness supervenes There may be incontinence of urine and the whole picture resembles closely that of an epileptiform attack. Mental charges may occur indeed many of these patients have been admitted to mental hospitals in the past under this mistaken diagnosis It is desirable in any patient who has epileptiform attacks to perform a blood sugar estimation during one of these in order to exclude the possible presence of an islet-cell tumour

Treatment The treatment of this condition is excision of the tumour This was first successfully accomplished by Roscoe Graham of Toronto in 1929 A transverse abdominal incision gives the best access to the pancreas, which has to be searched from head to tail since the tumour may occur in any part of it The pancreas is mobilized from the tail towards the head and the tumour which is often only a centimetre in diameter is first sought by palpation and then by inspection If none is found, the greater part of the pancreas should be excised in the hope that in so doing the tumour may also be removed

THE THYMUS

The function of the thymus is unknown. At birth it is a conspicuous bilobed fleshy structure lying in the anterior

m and it remains

conspicuous in size until puberty after which time it is usual for it to decrease until in adult life it is often scarcely recognizable In infancy and childhood it shows well on a skiagram but the concept previously held that it was responsible for pressure on the trachea is now known to be untrue The importance of the gland lies in the fact that it is in some way associated with the disease known as myasthenia gravis In addition it may be the seat of tumours benign or malignant

Myasthenia Gravis. In this condition there is progressive weakness of all the muscles of the body The eye muscles are often the first to be affected followed by those of mastication and finally those of locomotion. Diplopia slowing and slurring of the speech and difficulty in eating are often the first signs of the condition spontaneous remissions are usual The condition however is generally progressive and death finally occurs from pneumonia or asphyxia The diagnosis can be established by giving neostigmine, when there is an immediate return of muscle power to normal which may last for some hours. Patients symptoms can usually be controlled by taking neostigmine every three or four hours while the side effects of the drug can be controlled with ephedrine or atropine

Thymectomy The operation of thymectomy has been found to improve many of these patients considerably although the reason for this is not known. It can be expected that thymectomy will produce complete relief of symptoms in about a third of the patients treated a marked amelioration in the symptoms of a further third and probably no effect in the remainder The operation is best carried out during a remission and the patient is prepared by being given neostigmine to the point of tolerance. The administration of the anaesthetic requires considerable skill since paralysis of the respiratory muscles makes the post-operative period particularly difficult to manage The approach is by a short collar incision with a vertical extension the whole length of the sternum The latter is divided with a Lebsche chisel or bone cutters, the two halves being separated by a powerful retractor The pleura is gently pushed to each side and the thymus is then seen lying in the midline, its blood draining by means of a fair-sized vein into the left innominate vein. The thymus is removed by careful dissection and the two halves of the sternum wired together Care is taken not to open the pleuræ since this will necessitate subsequent aspiration of the pleural cavities and may make breathing even more difficult in the post-operative period. The after treatment consists in careful control of the dosage of neostigmine, removal of any excessive secretions from the trachea and bronchi and in severe cases of myasthenia, the use of an artificial respirator or iron lung.

In about 10 per cent. of these patients a tumour of the thymus will be seen in a lateral skiagram of the chest Such patients are best treated in the first place by supervoltage radiotherapy followed later by thymectomy It is unfortunately not possible to decide before operation which patients are most likely to benefit from thymectomy

Tumours of the Thymus. Since the gland consists of both epithelial and lymphocytic elements tumours may arise from either or both groups of cells. A benign thymoma may form a large rounded mass in the mediastinum which is readily seen in a skiagram. Malignant tumours are locally invasive and may produce metastases. Most of the tumours arising from lymphoid-like tissue are best treated by radiotherapy the others by excision. Good

access is obtained by splitting the sternum vertically or by bilateral thoracotomy dividing the sternum horizontally

It has been suggested that Hodgkin's lymphadenoma arises as a disease of the thymus and that its manifestations, especially those in the neck, are the result of its spread by the lymphatics. Although this is an attractive theory it is difficult either to prove or disprove. The treatment of Hodgkin's disease remains primarily in the hands of the radiotherapist recurrence being treated where necessary by the injection of substances such as nitrogen mustard.

Chapter 35

THE BREAST

Congenital Malformations

Congenital abnormalities are much more common than is generally supposed. One or more accessory breasts (*polymazia*) or nipples (*polythelia*) are found either below or just above the normal one sometimes they are found in the axilla, the inguinal region or on the outer side of the thigh They are often of a most rudimentary nature but in a few cases have secreted milk. Very rarely the breasts are entirely absent (*amazia*) Occasionally the male breast becomes enlarged to the ordinary size of a



FIG 35 1 AXILLARY BREASTS WHICH WERE QUITE FUNCTIONAL.

virgin s breast (*gynecomastia*) the organ is usually functionless, since the overgrowth mainly affects the stroma, although lactation has been known to occur The condition may be associated with imperfect or irregular development of the sexual organs, as in Klinefelter's syndrome

Diffuse Hypertrophy of the Breast. There is a general enlargement of the organ due to a diffuse overgrowth, chiefly of fibrous stroma and fatty tissue. The breast usually remains firm and elastic, but may reach enormous dimensions, occasionally to the extent of resting on the knees when the patient is sitting. The condition comes on about puberty and is generally bilateral The breasts are usually painless, although sometimes neuralgia is noticed Functionally they are useless as even if the patient becomes

pregnant, secretion of milk rarely occurs No cause can be assigned for the overgrowth.

Treatment The treatment of diffuse hypertrophy must vary from amputation to some form of mammaplasty X ray treatment and hormone therapy are useless Amputation is required in those cases where the whole breast is enormous and contains numerous cysts In other cases total mammectomy with free transplantation of the nipple and areola may be performed, while in those cases where it is desirable to reduce the size of the breast mammaplasty should be undertaken This operation is described in the chapter on Plastic Surgery

The Nipple

Fissures of the Nipple. Cracked nipples seldom occur apart from lactation and may usually be traced to a want of care and cleanliness on



Fig. 35 2. Absence of the Left Breast in a Girl aged 17



Fig 35 3 Diffuse Hypertrophy of the Breasts.

the part of the mother associated with a tender condition of the skin brought about by leaving the nipples wet after nursing. The superficial layers of epithelium become macerated and are easily rubbed off thus exposing the more delicate and sensitive deeper parts, which are irritated and inflamed by the repeated acts of suction As a result, nursing becomes painful, and if persisted in, the wound may be infected the inflammation spreading to the breast substance along the ducts or lymphatics, or extending along the superficial lymphatics to the axillary nodes.

Treatment The best way to prevent the occurrence of cracks is to bathe the nipples with some dilute antiseptic such as boric acid lotion immediately after nursing, and then to dry them thoroughly and apply lanoline which keeps them soft and supple. When a fissure has formed, the milk should be withdrawn by means of a breast pump

Areolar Abscess. This is not uncommon in young girls about the age of puberty. It arises in the sebaceous follicles and should be treated by incision.

Chancre. This condition used to be common amongst wet nurses though very rare in the mothers of syphilitic children (Colles's law). It presents as a shallow ulcerated surface with a well-marked raised and indurated border. Not uncommonly the condition is symmetrical. The axillary nodes are always enlarged and hard and sometimes form a large tender mass.

Keratosis of the Nipple. In this condition the nipple is replaced by a warty growth which constantly breaks off. The nipple disappears and is replaced by a depression filled with irregular horny masses. No satisfactory treatment has been discovered as yet, but X rays may prove beneficial.

Dermatitis of the nipple, sebaceous cysts and papillomata also occur.

Paget's Disease of the Nipple (*Eczema of the Nipple* or *Dermatitis Maligna*). This disease was first described by Sir James Paget in 1874 and since that date much controversy has taken place as to the exact pathology of the condition. It is known that the cancer commences in the epidermis and



FIG. 35.4. PAGET'S DISEASE OF THE NIPPLE.

that the change in the duct epithelium immediately beneath the surface is concomitant. Surface ulceration is never excessive. The epidermis of the eczematous area is reduced to a layer of a few cells and the dermal papillæ are destroyed. In the dermis the lymphatic vessels are often distended with cancer cells and are surrounded by a round-celled infiltration. Large epithelial vacuolated cells, the "Paget" cells, are characteristic of the condition. Although the condition may remain limited to the epidermis and ducts for some years, usually a scirrhous cancer forms in the substance of the breast. On clinical examination it presents a smooth, red, raw surface, discharging a yellowish viscid fluid, and may occasionally spread widely beyond the areola. The projection of the nipple disappears, the raw surface being absolutely flat. Lymphatic nodes are not involved, but the associated carcinoma follows its usual clinical course. No local treatment is of any avail, and the disease, when once recognized with certainty, is best treated by radical amputation including the axillary nodes.

Inflammation of the Breast

Acute Mastitis. This is most common in puerperal women of an anæmic, weakly type and usually results from a sore or cracked *nipple through* which pyogenic organisms find their way into the lymphatics or acini of the breast substance In the former case the inflammation is mainly interstitial in character the pus diffusing itself widely between the lobules in the latter the pus is primarily intra-alveolar In non puerperal women acute mastitis may result from injury or may be pyæmic in origin. Occasionally a metastatic inflammation of the breast occurs after the disappearance of the parotid swelling in mumps. The organism responsible for the infection is usually a staphylococcus, but occasionally it is due to a streptococcus.

Under this heading may be included certain conditions which arise out of a disturbance of normal endocrine processes. In this connection may be mentioned *mastitis neonatorum*, a condition not uncommon soon after birth. One or both breasts become swollen and tender and occasionally

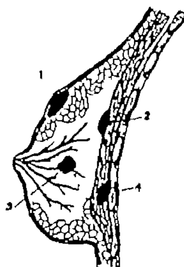


FIG 35 5 VARIETIES OF ABSCESS OF THE BREAST
1 Supramammary 3 Intramammary
2 Submammary 4 Retromammary

proceed to suppuration It is probably due to an active proliferation of the duct epithelium which takes place as a response to maternal œstrogenic influence. No special treatment is necessary unless suppuration takes place in which case an incision will be required

At a later period of life the breasts, or a portion of them, may become enlarged hard and tender giving rise to the *mastitis of puberty* The condition subsides after a variable period of weeks or months and should be treated medically

After parturition great swelling of the breasts occurs as lactation develops, owing to the fact that several of the ducts are blocked with epithelial débris. This is termed *milk engorgement* and may be accompanied by a rise of temperature The breast is dusky swollen, tender with prominent veins It should be treated by withdrawal of the milk through a breast pump.

Signs and Symptoms An inflamed breast is characterized by the organ becoming swollen acutely painful and tender The gland lobules are

enlarged and indurated and if lactation is progressing the secretion is to some extent impaired but *owing to the inability of the mother to allow the child* to relieve the organ on account of the pain produced thereby considerable tension results from accumulation of milk. If suppuration follows, the skin over the breast becomes red and œdematous, and according to the situation of the pus, three different forms are described (*a*) A *supramammary abscess* is a collection of pus in the subcutaneous tissues or beneath the nipple it is often unconnected with the organ and comes readily to the surface. (*b*) An *intramammary abscess* is the most common variety the *pus developing* within and distending the lobules or infiltrating the cellular tissue around *them* it is usually diffused widely throughout the organ and may point at several spots. When very acute or in debilitated women especially if it has been allowed to progress without treatment, the inflammatory process may actually determine gangrene of the glandular tissue (*c*) A *submammary abscess* forms in the cellular tissue beneath the breast It may spread from the deep lobules, but more frequently results from disease of some adjacent ribs or cartilages, or starts as a cellulitis. In these cases the breast is pushed forwards, and becomes *prominent floating, as it were, on a bed of pus.* The abscess usually points at the periphery of the organ, perhaps in several places but most commonly at the lower and outer quadrant

Treatment The early stages of mastitis are treated by supporting the breast and arm (in order to rest the pectoral muscle on which the breast lies) and administering penicillin 40 000 units four hourly should be given by injection Resolution commonly takes place and feeding may proceed. If however the condition continues to advance and an abscess localizes lactation should be stopped. Stilbœstrol 5 mg. thrice daily should be given *by mouth and a breast pump employed. An* abscess *should be opened by* one or more radial incisions and the cavity drained. With antibiotic therapy it is no longer necessary to lay open the abscess cavity in the manner recommended in the past.

In the supramammary variety it matters little in which direction the cut is made, since the pus is always superficial to the breast tissue. In the true intramammary abscess the incision should radiate from the nipple. A large *drainage-tube is inserted for a time and gradually* shortened day by day until its entire removal is permissible The submammary abscess is best opened towards the lower and outer side, but also at any spot where pus points

Encysted Chronic Abscess. This may follow an acute abscess which has partially resolved under penicillin therapy or may arise in connection with a retention cyst. It is characterized by the formation of an indurated *mass in the breast substance,* which *slowly softens,* giving rise to a sense of fluctuation although when the abscess walls are very thick, as is often the case, this may be difficult to detect. Retraction of the nipple *is not* uncommonly present, and the axillary nodes may be enlarged. Sometimes however it is possible to detect a feeling of elasticity at the centre, which is almost always less resistant than the margin whereas the opposite is the case with a tumour The introduction of a needle may determine the diagnosis but as with *any lump in the* breast of doubtful nature an exploratory incision and frozen section biopsy should be performed.

Fat Necrosis. This is an uncommon condition of doubtful *ætiology* It is possibly traumatic in about half the cases. The prominent feature is the

formation of a hard, painful area within the breast over which the skin may be slightly reddened and, in chronic cases, adherent and retracted. Section shows the hardness to consist of necrotic fatty tissue with much fibrous reaction and a few foreign-body giant-cells The condition is usually mistaken for carcinoma or an encysted chronic abscess.

Diffuse Tuberculous Disease of the Breast. This is now rare Scattered nodules of caseous material are developed in the interacinous tissue which break down into pus and come to the surface at various spots. The breast may thus become riddled with sinuses discharging caseous pus. It may be associated with tuberculous disease of the lungs, whilst a like affection may arise secondarily in the axillary nodes possibly in some cases the primary trouble lies in the nodes, the breast being subsequently involved. General chemotherapy for the disease is given and the breast is treated by incision and curettage.

Occasionally a *chronic tuberculous submammary abscess* forms as a result of disease of the ribs or costal cartilages. It develops slowly, pushing the breast forwards and is easily recognized, although its cause can only be ascertained by exploration. Aspiration may suffice for its cure although open treatment may be required for the affected bone.

Syphilitic Disease of the Breast. As already pointed out, a primary sore may be met with on the nipple secondary mucous tubercles, or condylomata, are found in a similar situation or beneath a pendulous breast, while superficial and deep gummata have in rare cases formed in the tertiary period of the disease.

Actinomycosis of the Breast. Primary actinomycosis of the breast is a very rare condition but several cases have been recorded. Multiple sinuses, retraction of the nipple, and fissuring of the areola are constant features in this disease. Local removal of the breast is the best form of treatment, combined with massive doses of penicillin.

Chronic Interstitial Mastitis

This well-established term describes a condition which occurs in women with small or atrophic breasts who have passed, or are near to the climacteric. It is also met with at an earlier age in unmarried women, involving the whole of one or both breasts, or limited in its development to a portion of one breast, and is then sometimes mistaken for a malignant tumour A better name for the condition is *cystic hyperplasia*

Pathology Though formerly thought to be of an inflammatory nature, there is little doubt now that the disease is endocrine in origin and due to an imbalanced action of the corpus luteum and the ovarian œstrin. The non-cystic type of nodular hyperplasia (*adenosis*) occurring in adolescents is generally agreed to be innocuous, but the multiple cystic variety is considered by many pathologists to be definitely pre-cancerous The essential feature in the process is hyperplasia of both the connective tissue of the breast and the epithelium (*epitheliosis*) It may have a lobar or a lobular distribution In the former the hyperplastic process is limited to one segment of the breast, giving rise to a swelling which strongly simulates carcinoma, and in the latter it is diffusely spread throughout the whole organ The diffuse overgrowth of the connective tissue around and between the acini renders the gland hard and knobbly Epithelial proliferation involves both the ducts and the acini at first the proliferated cells become detached into

the alveoli and collect in small cyst like spaces to constitute a colostrum like effusion Later on the cells remain attached to their base of origin and the alveoli may be choked up with this new formation Another stage consists in the growth of papilliform processes covered by epithelium which grow into dilated spaces. After a time the epithelial cells in any of these forms *may* change their type and become malignant in character and then penetrate into the connective tissues and constitute a cancerous growth. A certain amount of fluid exudate occurs within the acini, and may originate cysts in which the content is clear or turbid according to the number of



FIG. 35 6. CHRONIC CYSTIC MASTITIS OF THE BREAST WHICH ALSO CONTAINS A CARCINOMA, SEEN CLOSE TO THE PECTORALIS MAJOR MUSCLE.

cell-elements present. As a rule many of these cysts are scattered widely through the breast substance, but they are usually small and insignificant occasionally one of them becomes notably enlarged and simulates a tumour especially when covered in by a mass of thickened glandular tissue.

Clinical History The condition often passes unnoticed in the early stages, until a distinct lump has formed, which is nodular and indurated to the touch and often very painful A scanty serous discharge from the nipple is sometimes noticed The skin never becomes adherent to the swelling and the lymph nodes in the axilla may be enlarged and tender but they are never hard. On careful examination of the breast, the affection

is rarely found to be limited to one particular region for although a distinct enlargement of one portion may be present, yet the whole organ feels more or less "lumpy" and not infrequently the other breast participates in the same change. Small, rounded elastic spots can often be detected, and indicate the presence of cysts. There may be but little pain although this is sometimes one of the most marked features of the case it is of a neuralgic type and usually increased at the menstrual periods.

If left to run its course the disease may remain much in the same condition for many years and even in time disappear, but more frequently it slowly progresses, and then results in one of three conditions (a) *General atrophy* the breast becoming shrunken hard and nodular (b) More frequently *general cystic disease* follows, a condition in which the organ becomes transformed into a number of cysts held together by dense connective tissue occasionally a single big ("blue-domed") cyst is formed giving rise to a firm elastic swelling which is often tender (c) In not a few cases *cancer* is a sequel of this disease there is abundant evidence to prove that any continued source of irritation in an organ like the breast renders an individual with a cancerous inheritance more liable to its development, especially if it commences at or about the climacteric.

Diagnosis This is often easy but the condition may simulate somewhat closely a scirrhous tumour The chief points of distinction, however lie in the facts (a) that the whole breast is more or less involved (b) that the opposite organ is very often similarly affected (c) that the mass is adherent neither to the skin nor to the pectoral fascia (d) that it is more disseminated and less defined than a growth and is not palpable with the flat of the hand and (e) that if axillary nodes are present, they are not hard or clinically significant Small cysts can also be felt as localized spots in the inflammatory mass. Of course it is possible for the two conditions to coexist, for a careful microscopic examination of these breasts after removal often reveals the presence of a cancerous nodule when there is no clinical evidence of its existence.

Treatment In the early stages, and especially in the younger patients, friction with some sedative application containing belladonna may be used at the same time that the breast is supported Firm and equable pressure by a brassière is recommended. Stilbœstrol has been advocated but is thought by some to encourage any malignant tendency in the epithelial hyperplasia In cases where marked discomfort is a feature, or where there is a clear discharge from the nipple and no obvious area from which it comes benefit may occasionally be obtained by X ray treatment. But if a definite tumour is present, or if many cysts can be detected, and especially if the patient is anxious and worried about herself it is wise to remove the affected portion or even better to excise the whole breast, especially when there is a family history of malignant disease

Cysts of the Breast

When the structure of the breast its abundance of ducts and alveoli and its complex lymphatic distribution are considered it is not surprising that many different forms of cystic change are associated therewith The following are the more important

Acinous or Retention Cysts. These arise as a result of some obstruction to the ducts or lobules, whereby the secretion of the organ is unable

to escape They are met with most frequently in women during or after the puerperal period a milk cyst or *galactocele* being then produced It usually results from compression of one or more of the ducts connected with a sore nipple and contains inspissated milk It forms a rounded swelling and is located under the areola The wall is lined with epithelium and surrounded by a fibrocicatricial layer In old standing cases the fibrous wall becomes very dense and may cause retraction of the nipple and puckering of the skin closely simulating a scirrhus. The condition is treated by excision in the late cases, *but if seen early reacts to aspiration* and stilbœstrol.

Similar glandular cysts form as already described in the course of chronic interstitial mastitis, and in elderly women are known as *involution cysts* in long-standing cases general cystic disease of the breast may follow

Neoplastic Cysts. Cystic dilatation of the ducts and lobules frequently occurs in connection with tumours of the breast such as cystadenoma fibro-adenoma, duct papilloma and duct carcinoma. In these cases hæmorrhage from the contained growth is often seen giving rise to a blood-stained discharge from the nipple. Cysts are also seen in association with a carcinoma of the breast due either to degeneration of the centre of the growth or to the supervention of a carcinoma upon a cystic mastitis.

Interacinous Cysts. These arise in the interstitial tissue of the breast.

Serous Cysts These originate from a dilatation of lymph spaces They may be uni- or multi-locular perhaps more frequently the latter They are lined by a smooth shiny layer of endothelium and contain serum, sometimes blood-stained and, in old-standing cases cholesterin. They cannot be distinguished clinically from the cysts occurring in chronic mastitis, as a single cyst may go on developing in a mastitic breast with very little evidence of surrounding mastitis. If such a cyst is situated in the depth of the breast it may be difficult to diagnose it from a carcinoma, but if it occurs close to the surface it will not be adherent to the skin. Although the introduction of a hollow needle will show that it is a cyst that is present, it will be advisable to remove it because cystic degeneration may occur in a tumour and a carcinoma may sometimes arise in the wall of a cyst.

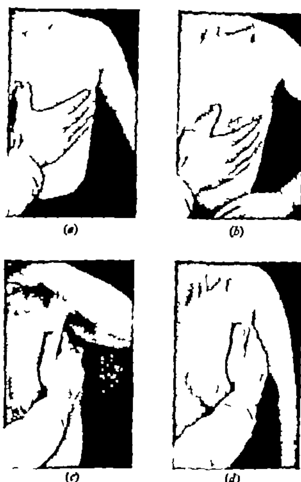
Hydatid Cysts These are occasionally met with and are usually larger than the single serous cysts of the breast. If one of these cysts is aspirated the fluid is colourless, but slightly opalescent, limpid, containing a trace of albumen and a considerable amount of sodium chloride. On examining the fluid microscopically the characteristic booklets of *Tænia echinococcus* if present, can be seen.

Additional help in the diagnosis of cysts may be found in transillumination of the breast or in radiography Occasionally the introduction of a contrast medium into a duct or cavity may allow a mammagraph to be obtained Such is, however more of academic than practical value

Tumours of the Breast

Clinical Examination. In any case of tumour of the breast, the surgeon should only give an opinion as to its nature after the most careful and detailed examination Thus, the age and previous history of the patient should be considered as also the family history Simple tumours generally arise at an earlier date than the malignant, whilst the sarcomata usually affect younger individuals than the carcinomata. There can be little doubt,

moreover as to the occasional tendency of tumours to run in families. The length of time for which the swelling has been observed should be ascertained, and whether or not it varies in size at the menstrual periods. The general appearance of the patient should be noted, as also the fact whether or not pain local or neuralgic, is experienced. It is not unusual for pain to be referred to that part of the shoulder supplied by the posterior division of the second intercostal nerve the anterior branch of which goes to the breast. A careful inspection of the organ should then be made with the patient



(a) (b)

(c) (d)

FIG 35 7 CLINICAL EXAMINATION OF THE BREAST

(a) Examination with the flat of the hand.
(b) Testing for fixation to the pectoral fascia.
(c) Examination of the axilla. The arm is abducted to allow palpation of the first intercostal space.
(d) Examination of the axilla. The arm is lowered to allow palpation of the rest of the axilla.

sitting and lying down comparing it with the opposite breast so that any signs of asymmetry may be noted Dimpling of the skin projection of the tumour or of the whole gland, and the situation and condition of the nipple, are the chief points to which attention should be directed. A useful test to detect asymmetry of the nipple is to make the patient raise both arms above the head. Examination of the tumour with the flat of the hand, accom

panied by gentle pressure of the finger tips must then be undertaken It is not enough to pick up the breast substance between the fingers as thereby false impressions are obtained. The relation of the tumour to the gland its shape its consistence whether fluctuating or not, and its mobility on superficial deep and surrounding parts should all be investigated To this end the breast must also be examined with the patient s hand pressed to the hip so as to put the fibres of the pectoralis major into action transverse movement of the organ across the fibres is always possible, unless the growth is fixed to the thoracic wall movement in the direction of the fibres is at once limited if the tumour has invaded the muscle or even if the overlying fascia is seriously involved Finally the regional lymphatic nodes in the axilla, supraclavicular and parasternal areas must be examined both on the affected and contralateral sides.

The chief types of tumour met with in the breast may be arranged in three groups the fibro-adenomata, the carcinomata and rare tumours. The latter include sarcoma, lipoma, fibroma, chondroma and osteoma, and *malignant melanoma*.

Fibro-adenoma of the Breast. This is the most common innocent growth.

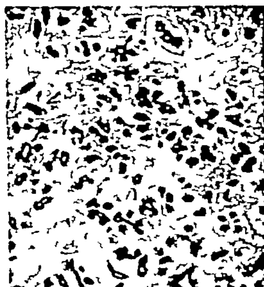


FIG. 35 8. PERICANALICULAR FIBRO-ADENOMA

It occurs mainly in two forms, the peri and intra-canalicular they are both characterized by the existence of spaces lined with epithelium which does not extend beyond the basement membrane. The *hard* (*pericanalicular*) *fibro-adenoma* shows increase in the interstitial tissue between the acini which, although narrowed, are still in most cases patent. Cellular infiltration and epithelial hyperplasia are frequently present In some cases the fibrous overgrowth is so marked that the ducts get squeezed out of existence and the tumour resembles a pure fibroma. On section the tumour is of a greyish-pink colour becoming pink on exposure to the air and the cut surface slightly bulging. It is more or less foliated in texture, being compared by Virchow to the section of a cabbage no juice can be obtained on scraping the cut surface with a scalpel, although on pressure some fluid of a thick glutinous or mucoid nature may escape. The tumour is distinctly encapsuled,

except at the one spot through which vessels enter and at which it is connected with neighbouring mammary tissue. The *soft (intracanalicular) fibro-adenoma* is caused by a marked increase of the cellular fibrous tissue beneath the epithelium which grows out from the wall of the acinus or duct in papillary masses which may occlude the lumen or determine cyst formation. The original fibrous stroma remains intact, or is stretched to accommodate itself to the new growth. The tumour is completely encapsulated, but it grows very rapidly and is very liable to undergo cystic degeneration



FIG 559 INTRACANALICULAR FIBRO-ADENOMA.

(cystic fibro-adenoma) a condition to be distinguished from cyst-adenoma a growth which is cystic from the start. This later stage is rarely seen nowadays as early removal has usually taken place

Clinical Features The fibro-adenoma is the most common mammary tumour met with in young people before the age of thirty it is often attributed to a blow or squeeze and doubtless correctly It occurs as a more or less rounded or oval mass, which, if placed superficially moves freely in the breast substance and indeed, may be described as floating in it if situated deeply it still appears quite movable, but its definition is less evident. Sometimes several such growths are found in the same breast. The hard fibro-adenoma is usually firm and more or less elastic in consistency of slow growth, and it may be either painless or in anæmic and neurotic women exceedingly painful the pain often increasing at the menstrual periods. The soft fibro-adenoma is usually of softer consistency and more rapid growth, forming an elastic and often fluctuant swelling. There is no concurrent enlargement of the axillary nodes unless arising from other causes and no retraction of the nipple, with which it is entirely unconnected the skin over it does not dimple

Diagnosis This is readily made if the above signs are considered An adenoma differs from chronic interstitial mastitis or a serous cyst by its exact definition and free mobility and its freedom from adhesions either to the skin or to surrounding parts. In women over forty great care should be taken, as an early malignant tumour may be mistaken for an adenoma.

Treatment Excision is advised and is easily effected by cutting down upon the tumour in a direction radiating from the nipple until the capsule is reached when the mass is enucleated from its surroundings with a few touches of the knife When the growth is situated deeply in the upper half of the breast a crescentic incision may be made along the lower and outer border of the organ and by burrowing upwards the breast can be turned over sufficiently to permit the tumour to be removed from the deep aspect the scar will be subsequently hidden

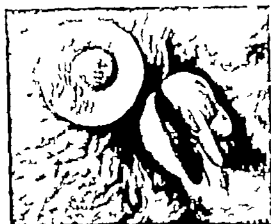


Fig. 35 10 Pericanalicular Fibro-adenoma of the Breast

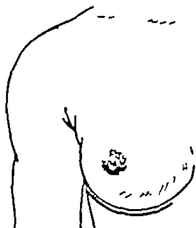


Fig 35 11 The Incision for Removal of a Fibro-adenoma.

Papillary Cystadenoma (*Serocystic Disease*) This rare tumour is characterized by a marked development of intracystic growths within the dilated acini of a newly-formed mass of adenomatous tissue or within the smaller ducts. It usually has a definite capsule and then the normal gland tissue may be pressed aside and perhaps atrophies. Several cysts are, as a rule, present, and may be of great size. The intracystic growths also vary some times there is only one large cauliflower like mass in a cyst sometimes there are several smaller pedunculated growths they are exceedingly vascular and hæmorrhage into the cavity of the cyst frequently occurs, as also a blood stained discharge from the nipple. The tumour produced is irregular or lobulated in outline, owing to the projection of the cysts It is usually painless, and unaccompanied by enlargement of the axillary nodes If of large size, blue veins are seen coursing over it. In the later stages the capsule becomes adherent to the integument, and finally owing to the pressure of the tumour the skin may give way allowing the growth to protrude. This will be followed by the development of a fungating mass, which bleeds readily and becomes extremely offensive With care a probe can be passed between the intracystic portion of the growth and the thinned and stretched skin, which has merely given way and is not incorporated with it this fact is a ready means of distinguishing this condition from a fungating malignant tumour The growth is essentially benign in nature it is never disseminated generally and, if completely removed, there is no recurrence. In the early stages it is often unnecessary to take away the entire breast, but in the later stages the whole organ should be excised.

Duct Papilloma. All gradations between innocence and invasive

carcinomatous change may be found. It is characterized by the development of a soft polypoid papillomatous mass *generally of small size in the interior* of one of the terminal galactophorous ducts which in consequence becomes dilated. A discharge of blood stained serum results, and there is usually no tumour to be felt although the nipple may be slightly pushed forwards and rendered prominent. Sometimes the affected duct may be identified by expressing blood from the nipple with a finger tip pressed against different

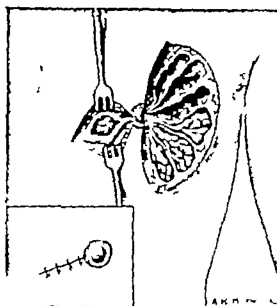


FIG. 35 12. DIAGRAM SHOWING REMOVAL OF A CYST CONTAINING A PAPILLOMA.

segments of the breast. If this can be done a strictly local excision may be accomplished, but often a partial or local mastectomy is advisable

Sarcoma of the Breast This is a rare disease (2 per cent. of all mammary tumours) It originates in the connective tissue of the organ being deeply placed in its substance or perhaps more frequently developing in the outer and upper quadrant *It is of two chief types (a) The round-celled sarcoma* forms a soft, somewhat elastic swelling, which grows rapidly and though often limited at first by a fibrous membrane, the capsule sooner or later yields, allowing the growth to become diffused through the organ It sometimes gives rise to secondary growths in the axillary nodes, or becomes disseminated throughout the body by means of the blood-vessels. Myxomatous changes are also not infrequently observed, and in the more rapidly growing recurrent tumours the mass is often a true myxosarcoma. It usually occurs in women between the ages of thirty and forty *i.e* somewhat earlier than carcinoma, whilst its rapid growth and the absence of retraction of the nipple or dimpling of the skin are useful diagnostic features. Should pregnancy follow the tumour may increase in size at an alarming rate. In the infiltrating form it is difficult to distinguish it from anaplastic carcinoma except on microscopic examination. *(b) A spindle-celled sarcoma*, or fibrosarcoma is also met with, forming a rounded or oval tumour more limited than above and growing less rapidly It somewhat simulates an adenoma but is more closely connected with the breast substance The axillary nodes are but rarely involved, and the sarcomatous nature is recog-

nized by the microscope and by the great tendency of the growth to recur even after apparently complete removal The recurrences generally take place at gradually diminishing intervals, and the tumour may then become softer and more vascular occasionally the tendency to recur seems to wear



FIG. 35 13 SARCOMA OF THE BREAST

itself out after the performance of several operations. Radical mastectomy followed by irradiation is the best form of treatment.

Carcinoma of the Breast

Ætiology The breast is the commonest site in the body for malignant disease, excepting only the stomach. In Great Britain about 8 000 women (and 80 men) die each year from this disease. The most frequent age is between thirty five and sixty but any age may be affected Rather more unmarried than married women develop cancer of the breast, and child bearing and lactation appear to confer a relative immunity On the other hand there is evidence in experimental animals that a breast-cancer producing influence can be transmitted in the milk of mothers of cancerous stock (the *milk factor* ') And in humans it is probable that heredity plays some part in the occurrence of the disease.

The expectation of life in untreated cases is about three years. Since early diagnosis is the key to the problem of more effective treatment, all women should be advised to examine their breasts with the flat of the hand at regular intervals and be encouraged to report any abnormal lump or sensation to their doctors, who in their turn are well advised to obtain a second opinion if in any doubt as to the nature of a lump

Pathology The relationship of chronic mastitis" to carcinoma has already been discussed. The majority of growths appear to arise in the acini and small ducts and histologically the same tumour may show a wide range of structure from well-differentiated papillary or adenocarcinomatous to diffusely anaplastic growth. In general terms growths may be called

(*a*) extraduct (spheroidal) (*b*) intraduct, or (*c*) metaplastic (mucoid). A rare variety appears to arise in the epithelium of sweat glands.

Extension of the disease takes place by (*a*) direct spread through the tissues (*b*) growth of cells along the lymphatic vessels and plexuses, the majority of which lie in the fascial planes (*lymphatic permeation*) (*c*) emboli in both lymph and blood streams Metastases appear in the regional lymph nodes the bones, especially the spine and upper end of femur and later in the viscera.

Direct Extension The skin overlying the breast may be infiltrated and ulcerated By extension of growth inwards the breast becomes adherent

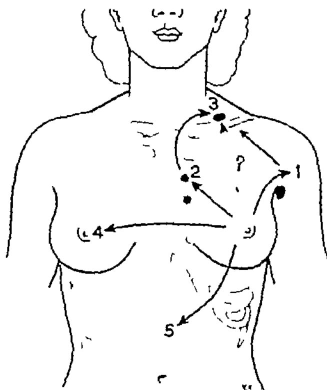


FIG. 35 14 THE LYMPHATIC SPREAD OF CARCINOMA OF THE BREAST
1 To the axillary nodes. 2. To nodes in the intercostal spaces and the anterior mediastinum (the internal mammary chain). 3 To the supraclavicular nodes from the axilla, the mediastinum and possibly from the breast direct. 4 To the opposite breast. 5 To the abdominal wall, liver etc.
Blood spread takes place to the lungs, long bones, liver brain, etc.

to the underlying fascia muscles, and chest wall. Nodules of growth may appear both in and under the skin and sooner or later the regional lymph nodes become infiltrated, enlarged, hard and matted

Lymphatic Extension. This occurs mainly through the medium of two lymph plexuses, one lying in the subcutaneous fatty tissue the other on the pectoral fascia From these plexuses lymph is carried by various paths—viz.

(1) To the axillary nodes, subdivided into four main groups (*a*) central, lying along the axillary vessels (*b*) pectoral deep to the pectoral muscles (*c*) subscapular on the posterior axillary wall and (*d*) subclavicular or apical, at the apex of the axilla

(2) To the anterior mediastinal nodes lying along the course of the internal mammary artery *via* the inner ends of the intercostal spaces The position in the breast of the primary tumour determines to some degree lymphatic spread. Thus when axillary nodes are involved with other quadrant growths it can be predicted that 25 per cent of patients will also have growth in the mediastinal nodes while with inner quadrant growths the figure is 35 per cent. If the axillary nodes are not involved then only 2 per cent. of patients will have mediastinal spread. This knowledge is clearly of importance when planning treatment.

(3) To the supraclavicular nodes, certainly by way of the anterior mediastinal lymphatics, possibly by vessels which pass in front of the clavicle and from the axilla itself

(4) To the opposite breast *via* lymph channels which cross the midline, and to the opposite axilla.

(5) To the lymphatics of the abdominal wall and *via* the umbilicus and ligamentum teres to the liver and peritoneal cavity

Blood Vessel Extension. It appears probable that metastasis to vertebræ ribs and skull occurs *via* the venous system rather than by arterial or lymphatic channels.

Signs and Symptoms. The upper and outer quadrant is most frequently involved, next in order being lower and outer upper and inner and finally lower and inner quadrants. *A lump in the breast of a woman over thirty five is a carcinoma until proved otherwise* This is the only early sign and by comparison the following signs must be considered late

(1) Localized mass of stony hardness with an irregular nodular surface, invading the breast tissue It is often noticed accidentally

(2) Adhesion to the skin leads to dimpling, puckering, nipple retraction and elevation of the breast

(3) The whole organ may be infiltrated and shrunken.

(4) The breast becomes adherent to the pectoral fascia and muscle and eventually to the chest wall.

(5) The axillary nodes are at first enlarged and stony hard, later becoming matted and ulcerated. The supraclavicular nodes undergo similar changes later

(6) When the primary growth lies to the medial side of the nipple, a secondary deposit sometimes appears early in the opposite breast.

(7) Paralysis of the arm severe pain radiating to the fingers, or solid œdema of the hand and arm may result from pressure of enlarged axillary nodes

(8) Dimpling and puckering of the skin overlying the breast may be followed by induration discoloration and ulceration the edges of the ulcer are hard and raised, the crater filled with fungating growth. Solid lymphatic œdema of the skin from blockage of lymph vessels produces *peau d'orange* the skin becoming thickened with coarse punctate depressions corresponding to the openings of the sebaceous glands Diffuse infiltration of the skin sometimes seen in the more rapidly growing types—*e g* encephaloid carcinoma—leads to *cancer en cuirasse* Multiple small cutaneous nodules are formed, with induration and reddish discoloration in the neighbourhood.

(9) Metastases in the liver produce jaundice in the lung dyspnœa and pleural effusion, in the peritoneum ascites, and in the bones severe and constant pain the ribs sternum, upper end of femur or humerus and the

dorsolumbar spine are the parts usually affected. Diffuse carcinomatous changes in the skeleton, with decalcification softening, and bending of bones, may occur (carcinomatous osteomalacia)

(10) Cachexia with sallow complexion and emaciation.

(11) Very rarely no tumour may be palpable in the breast, yet malignant nodes are present in the axilla.



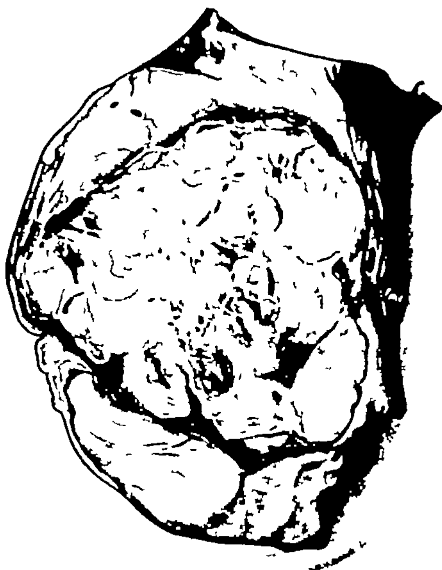
FIG. 35 15. CANCER EN CUIRASSE.
Note extensive ulceration, œdema of the arm due to lymphatic blockage of the axilla, and widespread skin nodules.

Clinical Varieties of Breast Cancer

It is generally recognized that the most vital factor in determining the outcome of the disease is the histological type of cell. A clinico-pathological description of the varieties of tumour is therefore appropriate.

Extraduct Cancer Spheroidal-celled growths comprise the majority of cases the division into *scirrhous* and *acute cancer* depends clinically on the rate of growth and degree of hardness, pathologically on the greater or lesser amount of fibrous stroma present.

Scirrhus This is usually first seen as a hard circumscribed mass, situated most commonly in the upper and outer quadrant of the organ. It is closely united to if not absolutely incorporated with the breast substance, and on careful digital examination its margin is quite indefinite. In the early stages it is entirely distinct from the skin which moves freely over its surface but as growth proceeds the stroma contracts, and by dragging on the suspensory ligaments of Cooper passing from the glandular substance to the skin the latter structure becomes more or less fixed, and hence, on attempting to move it upon the tumour an appearance of dimpling results. At the same time the whole breast is acted upon in a similar manner so that the affected organ sometimes seems to be smaller than the other and, since the upper half of the gland is usually affected, the nipple may be drawn



SARCOMA OF THE BREAST [University College Hospital Mus

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up so as to lie at a higher level than its fellow as well as being retracted from the drag of the growth on the galactophorous ducts The tumour itself is rarely of great size and is usually quite painless Occasionally it is tender and in the later stages may be painful the pain being of a neuralgic type extending to the shoulder and perhaps elicited only on manipulation As the growth increases in size it becomes adherent to the pectoral fascia and may even infiltrate the underlying muscular substance so that on examination with the pectoral muscle contracted it is found that although

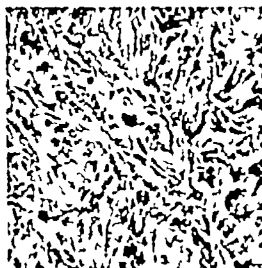


FIG. 35 16. SPHEROIDAL-CELLED CARCINOMA OF BREAST

movable across the fibres of the muscle the breast cannot be moved with them On section the tumour surface is concave, greyish-white with yellowish areas and sometimes small hæmorrhages It grates on the knife like an unripe pear

In elderly women a chronic form of cancer is met with known as *atrophic scirrhus* in which the disease lasts for many years without much definite extension. Cases have been known to persist for fifteen or twenty years, the patient at length dying of some intercurrent malady although in the great majority dissemination has ultimately occurred The special characters are due to the excessive contraction of the stroma as a result of which the cellular elements become crushed and practically destroyed The nipple is deeply retracted and the tumour and breast substance in the most marked cases are scarcely discernible

Acute Encephaloid Cancer This is fortunately not common and appears as a somewhat soft rapidly growing tumour which quickly infiltrates the whole organ and gives rise to secondary lymphatic and visceral affections at a much earlier date than scirrhous The stroma is scanty and on section the surface is soft homogeneous and greyish pink. It does not cause retraction of the nipple or dimpling of the skin the latter structure being distended with blue veins coursing under it The breast becomes enlarged and prominent the skin is stretched and gradually invaded by the tumour and, if ulceration follows, a foul fungating mass sooner or later sprouts up through the opening. This variety usually attacks young



FIG. 35 17 ATROPHIC SCIRRHOUS CARCINOMA, SHOWING AFFECTED BREAST SMALL AND SOMEWHAT SHRUNKEN WITH A LARGE ULCERATED AREA AND GROSS ŒDEMA OF THE ARM.

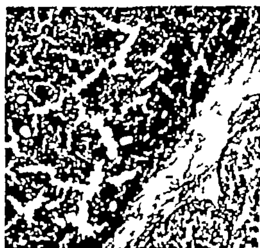


FIG. 35 18 ENCEPHALOID CARCINOMA OF THE BREAST

women under thirty five years of age and runs a rapidly destructive course.

Lactational Carcinoma This is a more diffuse variety of the encephaloid type seeming to involve the whole breast almost as soon as it is noticed The whole breast is swollen and hot and there is usually a rise in tem perature The condition which is rare, is often mistaken for acute mastitis and incised

Adenocarcinoma This is usually of an acinar type and has some of the characters seen in intraduct growths It develops slowly but frequently fungates through the skin and presents as a localized pedunculated growth



FIG. 35 19 ENCEPHALOID CARCINOMA OF THE BREAST

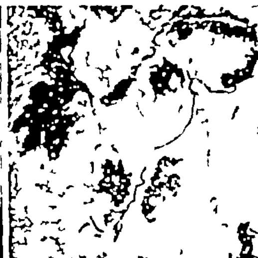


FIG. 35 20 MUCOID CARCINOMA OF THE BREAST

which readily bleeds. The axillary nodes are often free from invasion and the prognosis is relatively good.

Intraduct Cancer This is an uncommon form of the disease. It is sometimes characterized by the development of one or more nodules of a malignant papillomatous nature within the dilated ducts, and is usually situated not far from the nipple. It also not uncommonly supervenes upon a simple benign duct papilloma. These growths are covered with columnar epithelium and may indeed be looked upon as forms of columnar cancer They are exceedingly vascular and a blood-stained discharge from the nipple is usual. They always grow slowly and when situated near the skin give rise to a round dusky red swelling. The nipple is not retracted. They seldom give rise to puckering of the skin, and node involvement is not constant. *Carcinoma in situ*, the pre invasive carcinoma of the histologists, belongs to this group Clearly the prognosis of tumours which are still confined within duct boundaries is much better but many different sections of the breast must be examined before invasive growth can be excluded. It is such latter cases which account for the occurrence of widely disseminated blood stream metastases while the primary is yet trivial in size.

Metaplastic Cancer The term mucoid or colloid cancer is applied to tumours which show these degenerative changes. Although slow-growing,



FIG 35 17 ATROPHIC SCIRRHOUS CARCINOMA, SHOWING AFFECTED BREAST SMALL AND SOMEWHAT SHRUNKEN WITH A LARGE ULCERATED AREA AND GROSS ŒDEMA OF THE ARM.

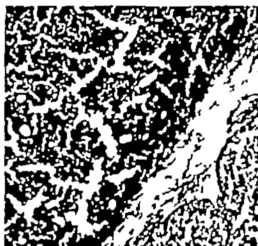


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Metaplastic Cancer The term mucoid or colloid cancer is applied to tumours which show these degenerative changes. Although slow-growing,

metastases occur as in other forms of the disease. Rarely squamous metaplasia may also be seen.

Carcinoma of the Male Breast. About 1 per cent. of breast cancers occur in men. Owing to the small size of the breast, the tumour is liable to infiltrate skin and muscles at an early stage of the disease. Radical mastectomy is a rather less satisfactory operation and the prognosis on the whole is worse

Diagnosis of Breast Cancer The established case of cancer is easy to distinguish from chronic interstitial mastitis, the adenomata, cysts and abscesses it is not easy indeed it is often impossible, to distinguish it from fat necrosis. It is therefore in the really early and most important stage that difficulties arise and the only safe rule to guide the clinician is that all lumps should be explored Here it is that a frozen-section examination is most helpful so that if the biopsy is positive the surgeon may proceed without delay to an immediate radical excision

Staging The clinical stage of the disease is now recognized as being of the greatest importance in deciding treatment and estimating prognosis. Several different classifications exist which, however vary only in detail. The following is acceptable

Stage 1 The growth is confined to the breast. The skin may be involved directly over the tumour provided the area is small in relation to the size of the breast. (This includes dimpling of the skin or retraction of the nipple.) There are no axillary nodes

Stage 2. There are palpable mobile axillary nodes. (The growth has spread to the axilla, but is still inside the nodes.)

Stage 3 The skin is invaded or fixed over a large area in relation to the size of the breast or the tumour is fixed to underlying muscle. The growth is still localized. Skin invasion takes one of two forms (*a*) *Peau d'orange* (*b*) ulceration Since in this stage the prognosis is considerably different according to the extent of lymphatic spread it may be further divided into Stage 3 (*a*) where axillary nodes are absent, and Stage 3 (*b*) where mobile nodes are palpable

Stage 4 The growth has extended beyond the breast area as shown by (*a*) Fixation or matting of axillary nodes (*b*) supraclavicular nodes (*c*) fixation of tumour to chest wall (*d*) multiple skin nodules (*e*) distant metastases in bone, lung or other breast etc.

Treatment of Breast Cancer

In recent years it has been acknowledged that results, as expressed in five-year survival figures, bear less relation to treatment method than had previously been supposed It has already been stated [illegible] prognostically the important factor is the histological [illegible] of cell T[illegible] few surgeons who insist that the more advanc[illegible] th the [illegible] the operation should be Therefore more pat[illegible] -day [illegible] combination of surgery and radiotherapy w[illegible] as hormone therapy and operations upon [illegible] Briefly a [illegible] lzе[illegible] be [illegible]

Stage 1 Most [illegible] ons [illegible] The operative det[illegible] d[illegible] 25 per cent. of ca[illegible] are f[illegible] apparent These [illegible]

minority of clinicians believe that as good results can be obtained by local excision of the tumour or local mastectomy combined with post-operative high voltage therapy (or the insertion of radium needles) to the breast parasternal axillary and supraclavicular areas

Stage 2. Surgery and radiotherapy should be combined Knowing that in over a quarter of patients whose axillary nodes contain growth the parasternal nodes are also involved the anterior mediastinum must either be dissected or irradiated There are technical arguments in favour of either radical mastectomy combined with post-operative therapy or pre-operative therapy followed by surgical excision.

Stages 3 and 4 Radiotherapy is the first method of treatment and most cases will derive benefit, both in regard to the primary growth and skeletal metastases, pain being frequently relieved and pathological fractures being enabled to unite. Surgery has also an important part to play Sometimes a post therapy radical mastectomy can be performed but more frequently some form of local palliative operation is done Ulcerating or fungating neoplasms can be excised but it is disastrous to cut across infiltrated skin or to operate in the presence of multiple skin nodules

The prognosis naturally varies with the clinical stage The outlook is good in Stage 1 80 per cent or more surviving five years Effective radical treatment should give a 50 per cent cure rate in Stage 2, but in the later stages only 5 or 10 per cent can be expected to survive Untreated, the average length of life is about three years

Operative Treatment This is advised when there seems a reasonable chance of eradicating the disease The contra indications for operation are extensive adhesion to the thoracic walls the presence of visceral deposits, and the extension of the disease to the supraclavicular lymphatic nodes or to any on the other side of the body In addition the encephaloid and lactational cancer or the presence of cancer *en cuirasse* or fungation suggests treatment by means of radiotherapy rather than surgery Œdema of the arm and pain due to involvement of the brachial plexus also form contra indications to operation. Atrophic scirrhus is often left alone in very old people on the plea that the prognosis is so favourable as to render treatment unnecessary If the patient is fairly strong, however there is no objection to operation and it certainly seems wise to remove a cancerous focus, however chronic it be Speaking generally rapidly growing tumours in vigorous patients are very unfavourable cases to deal with, whilst slow growth of the tumour and definite limitation of its outline are favourable signs.

Radical Mastectomy The patient lies on the back, with the head directed towards the opposite side, and the arm raised and held to a little more than a right angle. The incisions employed vary with the size and position of the tumour the primary object is to remove the growth together with the whole gland and all its accessible lymphatic connections the question of being able to close the wound subsequently is secondary As a rule, sufficiently wide undercutting will allow very extensive wounds to be closed but when this is impossible, skin grafting can be adopted and no lengthy convalescence need ensue

In planning the incisions, the growth should be taken as the centre and a circle with a diameter 10 to 12 cm made It is necessary to prolong the upper and lower portions upwards towards the axilla and downwards towards the epigastrium, so as to secure a straight line for the final suture

The dissection of the axilla is started first in order to avoid an unnecessarily prolonged exposure of the chest wall The skin flaps are undercut and retracted a transverse incision in the fascia at the level of the insertion of the pectoralis major is made the cephalic vein identified and the anterior border of the latissimus dorsi exposed. The upper lower and lateral limits of the axillary dissection are thus defined The pectoralis major is divided

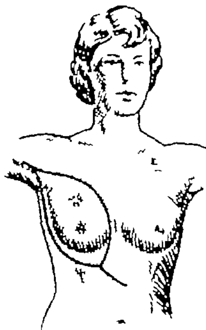


FIG. 35 21 RADICAL MASTECTOMY
The incision is outlined stippling shows the area of tissue removed.

close to its insertion and retracted inwards. The axillary fascia is incised so as to expose the axillary vein and the dissection is then carried upwards and inwards towards the clavicle The clavicular attachment of the pectoralis major is divided, and the insertion of the pectoralis minor severed close to the coracoid by drawing these down the axillary contents are exposed, and can be dissected away from the axillary vein together with the lymphatic area running up under the clavicle Care is taken to identify and if possible to preserve the nerves to the latissimus dorsi and serratus anterior muscles which are exposed in the posterior part of the wound.

The lateral skin flap is then undercut, and the whole breast and axillary contents drawn over towards the middle line the dissection is carried forwards and inwards, starting from the outer border of the latissimus dorsi. The inner aspect of this muscle is cleared as well as the axillary surface of the subscapularis. The subscapular nerves are identified and protected, and some branches of the subscapular vessels may need ligature The serratus anterior can then be denuded of the overlying fascia care being taken to secure branches of the intercostals, and finally the attachments of the pectoral muscles to the ribs and sternum are divided from below anterior and lateral penetrating branches of the internal mammary vessels being ligatured The midline of the sternum is thus reached a portion of the rectus sheath being included in the dissection The breast is then turned

back to its original position and the medial skin flap is dissected up across the middle line the advantage of doing this step last being that the vessels have already been secured in the deep dissection A few strokes with the scalpel then separate the fascia in the sternal midline and the breast and axillary contents are removed Great care is taken with hæmostasis as there is considerable oozing from such a large raw area and some surgeons prefer diathermy as a surer means of hæmostasis. The wound is drained through a stab incision in the posterior flap by a tube connected to a small bottle In this fashion the dressings are kept clean and dry and the wound need not be disturbed for several days It is advisable to place extra pads of wool in the axilla and under the clavicle so that their presence may assist

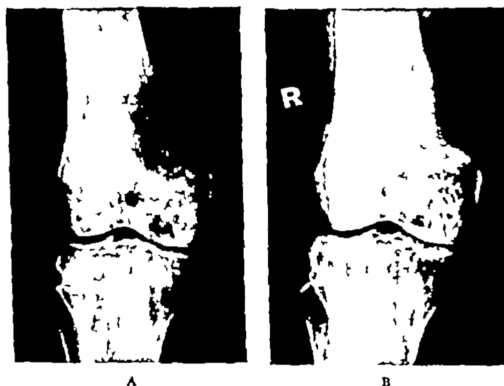


FIG. 35 22. METASTASES FROM CARCINOMA OF THE BREAST IN THE LOWER END OF THE RIGHT FEMUR.

A. Before bilateral adrenalectomy
B. Six weeks later Note almost complete recalcification.

in the prevention of oozing. If a collection of fluid does occur it should be aspirated through healthy skin and not drained through the wound The arm should be kept at an angle of 45° away from the trunk, so as to allow the skin flap to fall against the chest wall this does not interfere with the subsequent free movement of the arm.

If the anterior mediastinum is dissected the first four or five costal cartilages are divided and the sternum lifted medially The internal mammary artery is ligated above and below and the chain of lymph nodes along the artery dissected out with it.

Local Mastectomy The incision need not be so extensive but the skin is undercut in the same fashion and the whole of the breast tissue removed including the axillary tail. Most surgeons remove also the fascia covering

the pectoral muscle but if the operation is to be followed immediately by radiotherapy the fascia may be left Simple mastectomy may also be performed palliatively in some advanced cases and for these the incisions will have to be suited to each particular patient.

Endocrine Operations Bilateral *oophorectomy* is frequently recommended as part of the initial treatment in premenopausal women Experience has shown that irradiation of the ovaries does not necessarily stop the excretion of œstrogens and hence removal is to be preferred As a palliative procedure oophorectomy and bilateral total *adrenalectomy* are advised especially for those patients with widespread skeletal metastases causing severe pain This distressing symptom can often be most strikingly relieved. Massive growths and multiple cutaneous deposits, pleural and peritoneal effusions, may also on occasion show marked regression. It is clear that some growths are hormone-dependent and that removal of the sources of œstrogens is of benefit, if only temporarily The adrenal glands are exposed through incisions in the loins, the twelfth ribs being removed for better exposure. Before operation 200 mg. of cortisone and 5 mg. of desoxycorticosterone acetate are given intramuscularly together with salt by mouth. This is repeated in diminishing amounts following operation until the patient is established on a daily maintenance dose of about 50 mg. of cortisone. During the operation if the blood pressure falls, the level is maintained by an intravenous drip of noradrenaline

Some tumours which appear to be hormone-dependent and to regress after the above operations later advance again some remain unaffected from the first A factor of hypophyseal origin is therefore postulated and support is given to this view by the benefit which may follow *hypophysectomy* No tests exist which will indicate whether a patient is likely to benefit from operation on the endocrine glands but the excretion of ketosteroids and gonadotrophins in the urine may be of assistance. Likewise the state of the vaginal epithelium, which can be assessed from a smear is an index of œstrogenic activity A remission can be expected in 50 per cent. of patients.

Radiotherapy The place of radiotherapy is established It is known to be capable of eradicating the disease in some cases and of restraining growth for long periods in others. It is not necessary to describe techniques in detail. The following methods are available

High Voltage Therapy For radical treatment a dose of 4,000 to 6,000 r is recommended and three or four fields are used. It is easier to irradiate the breast (unless very massive) than a mastectomy scar but in addition the axilla, parasternal and supraclavicular areas require treatment. Prolonged treatment, taking as much as three months, produces less local reaction and no more general effect than the more usual five or six weeks course. Desquamation may be dry or moist but healing should follow rapidly after conclusion of treatment and complications like necrosis of costal cartilages or clavicle should never occur Palliative H V T is also extensively employed for advanced primary lesions and for localized deposits in bones

Radium Therapy Interstitial needling is applicable as an alternative to irradiation by X rays That is to say the breast itself and the same regional lymphatic areas must be implanted with needles in a geometrical pattern so that a uniform dosage is given. In practice this may mean that as many as fifty to sixty 2 or 3 mg. needles are employed. The method is time-consuming and has largely been replaced by external irradiation Needling

has, however, a place as a local treatment in the advanced primary lesion when reduction in bulk and healing of ulceration may result

Isotope Therapy Certain metastases are not treatable by conventional surgery or radiotherapy Pleural and peritoneal effusions for example, can sometimes be improved by aspiration and replacement with radioactive colloidal gold The equivalent of 100 millicuries in saline is inserted and the patient "rocked" so that the fluid is evenly distributed in the thoracic or abdominal cavities



FIG. 35 23 ŒDEMA OF THE ARM FOLLOWING RADICAL MASTECTOMY AND POST OPERATIVE HIGH-VOLTAGE THERAPY

Hormone Therapy The removal of the sources of œstrogens in the body (the ovaries, adrenals and anterior lobe of the pituitary) has been discussed. The same sort of effect may be obtained by the administration of androgens. Where there are multiple skeletal deposits, particularly in pre menopausal women healing by sclerosis with consequent alleviation of pain may be obtained by giving testosterone. This is given as testosterone propionate by intramuscular injection 100 mg. two or three times a week or as methyl testosterone by mouth, 50–100 mg. daily Paradoxically the administration of stilbœstrol is also often effective for the treatment of ulcerating scirrhous lesions in elderly women This is thought to act by inhibiting the anterior pituitary Large doses 15–25 mg. daily should be given.

Chapter 36

THE LUNG AND PLEURA

The Pleural Cavity

Normally both layers of the pleural membrane are in apposition, the surface of the lung being held against the parietal pleura by the subatmospheric pressure of the pleural cavity If air effusion blood or pus is present within the cavity the lung retracts or is pushed away from the chest wall Absorption of air or removal of the fluid enables the lung to re-expand.

Pneumothorax. The commonest form of pneumothorax is encountered at thoracotomy when the chest is opened and the parietal pleura incised. Air enters the cavity through the wound and an " open " pneumothorax is created Other forms of open pneumothorax are seen in penetrating wounds of the chest wall.

Closed Pneumothorax This occurs when air enters the cavity without their being any external communication. Puncture of lung, rupture of an emphysematous bulla or pathological ulceration of lung (pulmonary tuberculosis) are common causes.

Artificial Pneumothorax This is used in the treatment of pulmonary tuberculosis and consists in admitting measured volumes of air into the pleural cavity through a needle at intervals of one to three weeks The refills are required because the air is slowly absorbed from the pleural cavity

Tension Pneumothorax If air continues to accumulate as the result of a persistent leak at the lung surface, the lung becomes more and more compressed and the mediastinum is displaced to the opposite side causing serious respiratory distress. The apex beat of the heart is displaced and the angle of the trachea in the suprasternal notch is altered The affected side of the chest may show bulging, there is a hyper resonant or tympanitic percussion note and absent breath sounds. This form of pressure or tension pneumothorax can become dangerous to life unless relieved

Treatment If air is present in any quantity it must be removed to relieve pressure This is simply performed by aspiration through a needle passed into the pleural cavity between the ribs An artificial pneumothorax apparatus is of value in removing the air and at the same time checking the intra pleural pressures.

A tension pneumothorax in which air accumulates rapidly causing acute distress can in emergency be treated by leaving a small needle in the chest wall or by insertion of a small catheter attached to a waterseal or suction apparatus. The first or second interspace anteriorly about 1 inch (2 5 cm) from the sternal margin is a safe site

Pleural Effusion. The pleura reacts to irritation or inflammation by producing an effusion which contains a variable amount of fibrinogen.

Simple effusions which do not proceed to suppuration are usually tuberculous in origin and resolve slowly Pressure of lymph nodes at the lung hilum as a result of carcinoma or multiple secondary nodules on the pleural surface also produce persistent effusions which are frequently blood stained Inflammatory effusions which would proceed to pus formation are often sterilized by the early use of antibiotics and present as slightly turbid effusions.

Treatment Effusions should be aspirated for diagnostic purposes, the bacteriology and cytology being studied in detail in an attempt to discover the cause. Other investigations such as sputum examination and bronchoscopy will probably be required in addition

Removal of an effusion (without the admission of any air through the aspirating needle) is indicated when the effusion is of any size If left *in situ* fibrin from the effusion is deposited on the lung and chest wall surfaces with the result that movement is restricted and re-expansion of the lung delayed

Hæmothorax. Blood can gain access to the pleural cavity from the lung and chest wall Injury is the most common cause and in warfare penetrating wounds which may damage the great vessels, heart and liver in addition to the lung and chest wall are common causes of considerable intrapleural hæmorrhage. If the lung is punctured or if the pleural cavity is opened to the exterior air gains entry so that a hæmopneumothorax is produced Pressure or tension effects occur if the volume of blood and air exceeds 4 pints and thus add to the severity of the condition, already made serious by loss of blood Blood-stained effusions due to malignant disease and tuberculosis have already been mentioned

The behaviour of blood in the pleural cavity deserves comment. The blood clots normally but the movements of the heart and lungs rapidly defibrinate the frothy mass to leave liquid blood which can be withdrawn through a needle. If the blood is allowed to remain in the pleura it causes a chemical irritation producing a fibrinous exudate which after two to three weeks induces secondary clotting and deposits fibrin in the fluid mass

Treatment If active bleeding continues, or if there are complicating factors as may occur with penetrating wounds, an immediate thoracotomy should be performed. Internal damage is repaired at the same time as the bleeding is arrested and all free blood is sucked out before the lung is re-expanded. Blood loss will have to be fully replaced by blood transfusion and energetic treatment instituted to counter shock.

The ideal treatment of a closed hæmothorax is to aspirate all the liquid blood completely within twenty four to forty-eight hours. The aspiration of several pints may take up to half an hour and no air should be allowed to enter the pleural cavity Air rises towards the apex and allows the upper lobe to collapse thus leaving a space which is much harder to obliterate than one at the base A two-way tap between the syringe and needle is the most efficient means of preventing an air leak.

If the fluid has undergone secondary clotting, complete aspiration is not practicable but liquefaction can be achieved by injecting a fibrinolytic enzyme (streptokinase) After this aspiration may be possible, but if the fibrin has become organized a thoracotomy is necessary to evacuate the clot and to peel off the fibrin masses (decortication) that are impeding the expansion of the lung. An untreated hæmothorax will inevitably lead to contraction and flattening of the chest wall with loss of underlying lung function.

Injuries of the Chest

The complications of chest injuries have largely been considered under the headings of pneumothorax and hæmothorax but there are certain comments that can be made in connection with the common forms of trauma.

Fractured Rib This can be produced in two ways. First by direct violence from a comparatively concentrated blow such as a kick from a boot, and second from "springing" of the rib hoop if the barrel of the chest is suddenly compressed. With direct violence, the sharp fragments of rib may be driven inwards and puncture the lung and form a pneumothorax which is not often serious. The main features of a fractured rib are pain and a desire to immobilize the chest and prevent movement (particularly coughing)

Treatment The standard teaching that a fractured rib should be strapped firmly is to be condemned Though the injury will have broken the bone the fragments are well splinted by adjacent ribs and intercostal muscles. Moreover the pressure of strapping may drive the fragments inwards and into lung tissue Treatment should be an injection of local analgesic solution, radiant heat or some form of physiotherapy and active inspiratory movements of the chest wall. The bone will unite quickly though the patient may not be able to lie comfortably on the affected side for four to six weeks.

Multiple Fractures of the Ribs. These result from massive crush injuries as may occur if the chest is violently compressed Motor-car accidents, buffer injuries on the railways, a charging bull and being caught between closing doors are examples of this type of injury which is also associated in many cases with internal injuries to the lungs and heart The problems of hæmothorax, tension pneumothorax and atelectasis have already been mentioned but special consideration has to be given to the actual chest wall if the fractures are so extensive that a section of the chest wall has lost functional continuity with the main outline of the thorax, the so-called stove in chest. Fracture of four to six ribs anteriorly and posteriorly leads to a loose lateral area that moves paradoxically on respiration. If this is not controlled, the whole physiology of respiration is disturbed and blood that cannot be ejected from the lungs leads to atelectasis which can become lethal.

Treatment The treatment of a "stove-in" chest must aim at preventing the physiological complications produced by the movement of the loose section. In emergency a firm pad strapped so as to produce immobilization is adequate. A quickly made plaster of Paris slab strapped over the area is even more efficient, but any method which presses the loose segment inwards will ultimately lead to some loss of respiratory function If facilities are available, the loose area of chest wall can be held in its normal position by traction. Two or three towel clips passed round ribs are attached to weight extension for two to three weeks, at the end of which time sufficiently firm union of ribs will have occurred. Alternatively an open operation with wiring of the fractured ribs can be attempted In addition aspiration of all bronchial secretions by a bronchoscope is necessary if atelectasis and subsequent pneumonia is to be avoided.

Penetrating Injuries. Penetration of the chest wall by a missile is common in warfare and if there is no extensive internal damage, which might cause immediate death, there will inevitably be the formation of a pneumothorax

and becomes more obviously purulent large flakes of fibrin (so-called lymph masses) are seen. About the tenth or fourteenth day when a considerable quantity of fibrin has been laid down the margins at which the lung touches the chest wall will have become adherent and sealed off thus leaving a localized collection of pus, the true empyema or localized abscess. The lung is collapsed according to the quantity of fluid within the pleural cavity and the fibrin lying on its surface tends to prevent re-expansion as it becomes thicker firmer and more organized. If the pleural abscess is not drained the organization of the fibrin progresses and later cicatrization leads to actual contraction of the chest wall with an associated scoliosis In addition to the local changes there are constitutional changes due to the retained pus rise of temperature and pulse rate, malaise secondary anæmia and even clubbing of the fingers may develop

Physical Signs. The physical signs of an empyema in the early stages are those of pleural effusion accompanied by toxæmia There is loss of movement dullness to percussion absent breath sounds and loss of vocal fremitus. When there is an excess of fluid the mediastinum will be pushed over and is invariably accompanied by a raised pulse rate and shortness of breath Other signs include leucocytosis and a raised erythrocyte sedimentation rate. If the empyema is untreated the loss of movement and flattening of the chest wall become more definite and sometimes permanent. On occasions pus may find its way to the surface through one of the inter costal spaces and produce fluctuation under the skin (empyema necessitatis). Pus may also rupture into the lung and be coughed up such drainage being usually accompanied by lung damage in the form of bronchiectasis.

A total empyema indicates one in which the whole pleural cavity is involved. A localized or loculated one presents on radiography as a rounded or oval shadow against the chest wall in any part of the thorax. An inter lobar empyema lies within one of the fissures and takes on an oval or fusiform shape.

The type of invading organism has an influence on the behaviour of the condition. Streptococcal empyema is characterized by an early voluminous effusion with little deposition of fibrin and late localization Pneumococcal and staphylococcal infection develop late but localize readily with the forma tion of massive fibrin deposits (the so-called lymph masses) Antibiotics by eliminating bacteria also remove bacterial enzymes which have a con siderable effect in breaking down fibrin, consequently many treated strepto-coccal empyemas show an unduly heavy deposit of fibrin

Diagnosis. There is only one satisfactory method of diagnosing an empyema and that is by aspiration of pus from the pleural cavity through a needle. The site of aspiration is determined by clinical examination *e.g* dullness, loss of breath sounds and radiological investigations. The pus which is withdrawn may give considerable information as to the character of the empyema if it is thin it will come easily through the needle if it is thick and the needle blocks there will be considerable quantities of fibrin within the cavity An offensive odour or the presence of air suggests the possibility of anaerobic infection although air can be present as the result of a fistula into the lung. Bacteriological investigation is essential in all cases to establish the character of the infection. Certain organisms tend to produce different types of pus. Pneumococcal pus is usually thick and fibrinous, as also is that due to staphylococci. A thin abundant fluid may

result from streptoccal infections and grey stinking pus from anaerobes or coliform organisms

It is unfortunate that many cases of empyema are not diagnosed until late, the physical signs of the effusion having been masked by the underlying causative pulmonary inflammation this is particularly the case with children. At the present time with the widespread use of antibiotics a number of empyemata are aborted or sterilized by the time that the pus is organized and aspirated This however does not imply that rigorous and adequate treatment should be neglected

Treatment. In the early stages of diffuse suppuration the fluid can easily be removed through a needle which as well as removing the products of infection encourages the lung to re-expand In the later stages where there is a thick fibrinous wall there are additional difficulties because of the thickness of the pus.

The essence of all treatment is to remove the pus and thus relieve the patient of the effects of toxæmia and secondly a point that is often neglected to obtain obliteration of the cavity which can only be done by encouraging re-expansion of the lung. The chest wall is rigid and will not collapse as for example in the case of an appendix or pelvic abscess The first step in treatment, which will probably have already been undertaken for the pneumonic condition, is the full use of appropriate antibiotics and during the whole course of chemotherapy attention must be paid to the general condition of the patient and any tendency towards anæmia corrected, if necessary by blood transfusions. Apart from this the two main methods of treatment are aspiration and drainage.

Aspiration This is a form of intermittent drainage whose limitation is the lumen of the needle through which the fluid is withdrawn Thin fluid can easily be removed by a fine needle and syringe thick pus may not flow through a much wider bore needle The essential feature of efficient aspiration is to remove all the fluid from the pleural cavity and not to admit any air during the process. To facilitate this a two-way tap should be used between the needle and syringe. The skin and intercostal tissues are infiltrated with local analgesic solution prior to insertion of the needle. The actual aspiration may take up to half-an-hour if more than a pint of fluid is withdrawn.

Aspiration is repeated as often as fluid collects until the pleural cavity is completely dry or until pus no longer comes through the needle because it is too thick. The time has then arrived for a more permanent form of drainage.

Drainage This is carried out after rib resection which provides room for a tube of adequate size and at the same time gives an opportunity for inspection of the interior of the abscess and removal of any retained fibrin mass. The tube is placed at the most dependent point of the abscess and is kept there until the lung is fully expanded and the abscess cavity obliterated Lung re-expansion is encouraged by special breathing exercises which aim at inspiratory effort.

Progress is determined by skiagrams taken in two planes after the cavity has been filled with a radio-opaque oil (pleurograms). The necessity for any alteration or adjustment of the drainage tube can then be gauged. Frequent changing of the tube is to be deprecated the most common cause of chronic empyema is failure to establish and maintain adequate drainage.

There is no necessity to keep any patient bed-ridden once the signs of toxæmia have disappeared. Movement and exercise are essential for recovery.

Chronic Empyema. Chronic empyema usually results from maltreatment of the acute phase though tuberculosis and new growth are occasional causes. An analysis of the causes of chronic empyema shows that inadequate drainage is by far the most important factor. Delayed drainage or drainage in the wrong site also contribute to the chronic condition, but too early removal of the tube or too small a tube draining a large pleural abscess is the feature that in the past contributed to this disabling state of affairs. Retained foreign bodies or a rib sequestrum are relatively rare causes.

A chronic empyema is a crippling condition. Not only is there pleural suppuration and toxæmia, but the lung is bound down and does not function and the contraction of the thoracic cage may lead to severe scoliosis. Chronic ill health, anæmia and clubbing of the fingers result, in addition to the discomfort of a persistent, purulent and often offensive discharge which requires frequent dressing.

Treatment. The first steps are to ensure adequate drainage and investigate the cause. Bronchoscopy, sputum examination and bronchography will be required if there is any doubt that the empyema has a persistent primary cause. An unsuspected lung tumour, abscess, tuberculosis or bronchiectasis may be discovered. A minor thoracotomy involving resection of a short length of rib is performed, the thickened parietal pleura is excised and sent for histological examination, the cavity is cleaned out and a wide-bore tube inserted at the most dependent point. Active and intensive breathing exercises are initiated and any anæmia is treated by blood transfusions. There is usually an immediate relief of toxæmia, the discharge becomes minimal and the patient is encouraged to be as active as possible. Adequate drainage is required in all cases.

A number of thoracoplastic and pleuroplastic operations have been described for the treatment of long-established chronic empyema but these are practically unnecessary (except in the presence of tuberculosis) so long as adequate drainage is persisted with and breathing exercises efficiently carried out. It may take months to obliterate the cavity but the end result will be a healed empyema and a functioning lung, whereas plastic operations will lead to a deformed chest and loss of function.

In some instances, particularly where there is a heavy deposit of fibrin and when the empyema contents have been sterilized by antibiotics, it is possible to excise the walls of the empyema and thus remove the restriction to lung and chest wall movement. The original operation was called decortication and in this the empyema cavity was laid freely open and the organized layer of fibrin over the lung peeled off by a combination of blunt and sharp dissection. This procedure has been elaborated so that after a thoracotomy the thick layer of fibrin and fibrous tissue is dissected off the inside of the chest wall. Next the margins of the empyema are cleared and finally the layer over the lung is removed. Considerable oozing of blood and small air-leaks from the surface of the lung necessitate suction drainage by at least two tubes until the lung has completely expanded. The operation is of moderate severity but it may save the patient weeks of disability. This operation of pleurectomy is also valuable in chronic hæmothorax.

Bronchial fistulæ arising in the course of empyema treatment are not significant unless caused by new-growth or tuberculosis; they heal spon-

taneously with continued drainage. Their presence can be detected by instilling methylene blue (1 per cent solution) into the cavity and recognizing the colour of the dye in the sputum.

Bronchiectasis

The term bronchiectasis *implies dilatation of the bronchi* a condition that can only be recognized radiologically The clinical discovery of bronchiectasis depends upon infection of the dilated bronchi with the production of *purulent sputum* Bronchiectasis may involve any part of the lung fields It is frequently localized to a segment or lobe but may have a more diffuse distribution commonly affecting the lower lobes.

Bronchiectasis usually follows persistent atelectasis or active collapse of lung tissue. This collapse is caused by obstruction of a bronchus which is produced by a variety of circumstances inhaled vomitus or blood foreign bodies, intrabronchial neoplasm or pressure from enlarged lymph nodes Beyond this obstruction the enclosed gases in the lung are absorbed and the affected area becomes airless and solid This mass of collapsed lung exerts traction on the surrounding tissues and stagnation in the bronchi predisposes to infection with softening of their walls. The absence of drainage in the dilated bronchi causes them to resemble sumps which collect pus and this is the origin of the cough and yellow sputum that characterize the disease. In the later stages, peribronchial inflammatory changes lead to fibrosis and prevent any possibility of the lung re-expanding.

The anatomical forms of bronchiectasis are referred to as cylindrical saccular glove-finger cystic and so on The shape depends on the size of the bronchus that is affected a large bronchus with rigid walls is less liable to be stretched or dilated than a fine bronchus whose softer walls can be extended into a cyst-like structure.

Signs and Symptoms. The history of bronchiectasis frequently dates from some past lung inflammation particularly the pneumonia which accompanies measles or whooping cough *and once established the condition* becomes progressive and increasingly incapacitating. The dilatations are not reversible.

The principal features of bronchiectasis are cough and purulent sputum, although in the absence of infection the symptoms are minimal. The character of the sputum is the best indication of the severity of the condition. Yellow sputum (which indicates pus) varies in volume from a trace each day to several ounces or even a pint. It frequently tastes foul and may be frankly fœtid indicating stagnation. Hæmoptysis is a common feature indicating bronchial ulceration, but is rarely of sufficient volume to be alarming.

The general appearance of the patient varies with the degree of infection loss of appetite, asthenia and pallor are common the fingers may show clubbing. Shortness of breath may be noted and if the patient develops a cough or cold there is invariably an increase in the amount of sputum. Patients complain of being permanently "chesty" and "wet" and their persistent cough is a source of annoyance to others. So-called attacks of pneumonia are likely to occur whenever there is marked retention of bronchial secretion and in the later stages the lung fibrosis and shortness of breath add to the disability of the already toxic patient.

The physical signs of established bronchiectasis are those of dullness to

percussion, usually over a limited area. Auscultation reveals anything from diminished breath sounds to bronchial breathing.

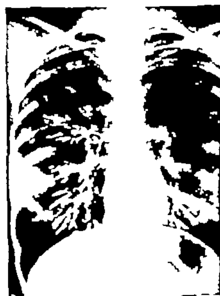
Treatment There is no radical treatment for the condition other than surgery but a great deal of benefit can be obtained and maintained by properly organized conservative measures. No decision as regards the treatment or prognosis can be made until the extent of the bronchiectasis has been assessed by the use of bronchograms. These, if carefully done,



A



B



C



D

FIG. 36 2. THE USE OF THE BRONCHOGRAM IN THE DIAGNOSIS OF BRONCHIECTASIS.

A and B. Normal bronchograms. The importance of the lateral view in distinguishing branches that are running anteriorly or posteriorly is clearly shown.

C and D Bronchograms showing bronchiectatic changes in the anterior segment of the upper lobe, middle lobe, apex of lower lobe and all the basal branches.

show the extent and size of the dilatations and enable the surgeon to consider the possibilities of operation Figs. 36 2 A and B illustrate a normal bronchogram the importance of the lateral view will be seen. Figs 36 2 C and D show a corresponding bronchogram in a patient with bronchiectasis

In every case, whether surgery is contemplated or not a prolonged period of physical treatment is necessary This consists of postural drainage in which the bronchiectatic dilatations are positioned so that they can drain under the influence of gravity The patient must be placed in the correct position and the treatment should be persisted with for hours on end so that thick secretions can be evacuated and the affected areas remain more or less dry At the same time breathing exercises and other physiotherapeutic measures may help to clean up the infected areas aided by the judicious use of antibiotics. Examination of the oronasal tracts should be carried out to ensure that there is no gross source of upper respiratory tract infection.



FIG 36 3 GROSS CYSTIC BRONCHIECTASIS OF THE LEFT LUNG. Both lobes are affected. The right side shows little abnormality

If the disease is localized to a segment or lobe, surgical excision of the damaged area is the most effective procedure. The operative mortality for lobectomy in bronchiectasis is between 1 and 2 per cent. and the complication rate is not high. The disease is not, however always sufficiently localized to allow a radical operation and the success of surgery diminishes with the amount of lung which has to be removed, particularly if the disease is bilateral.

Palliative Operations Operative surgery in which gross areas of damaged lung are removed without excising all the bronchiectatic tissue, will reduce the patient's sputum considerably and may be of value in patients in whom the volume of sputum and exhaustion caused by coughing is marked. The most satisfactory age for operation is in childhood or early adult life

younger children do not co-operate well in after-treatment and results are less good in middle age

The operation of lobectomy is a standard procedure which consists of opening the thorax through a long intercostal incision and after spreading the ribs, freeing the affected lobe from any adhesions that may be present. When the damaged lobe has been isolated the root of the lung is carefully dissected to identify individual bronchi and pulmonary vessels. Appropriate structures at the root of the diseased area are divided between ligatures and after the lung fissures have been deepened the lobe is removed The most important stage in the operation is the suturing of the divided bronchus so as to render it airtight covering it with a flap of adjacent tissue. The pulmonary vessels are controlled by simple ligature and any air leaks from the lung surface closed The chest wall is closed and a waterseal drain inserted in the base of the pleural cavity

Residual lung tissue distends to fill up the dead space within a short space of time and any effusion or air is removed by the drainage tube which is kept in place until the hemithorax is completely filled by lung tissue and there is no free pleural space *i.e* two to four days. The dangers of the operation are not shock or hæmorrhage but later complications, especially atelectasis and bronchial fistula Atelectasis is likely if secretions are not promptly coughed up Cough is inhibited by the pain of the incision and sputum is therefore not always adequately removed Good nursing and postural drainage may remedy this but sometimes bronchoscopy has to be carried out to clear the air tubes and allow the collapsed lung to re-expand. Bronchial fistula, which used to be a serious complication at about the tenth or twelfth day is now rare, but when it does happen infection of the pleural space occurs. This can usually be cured by drainage.

The results of lobectomy for localized bronchiectasis are excellent, the operative mortality is negligible and the patient loses the cough and sputum and is free from the effects of toxæmia. Removal of more than one lobe can also give satisfactory results, but where diseased tissue is left behind cough and sputum persist.

Abscess of the Lung

An abscess forming within the lung is much less common now than it was formerly largely as a result of the introduction of antibiotics indeed surgical treatment is rarely required Three types of abscess may be recognized (*a*) as a result of breakdown in a zone of pneumonitis, (*b*) as a result of pyæmia when metastatic abscesses develop in the lung, and (*c*) the most important, an obstructive form of abscess. In this last form a segment of lung is affected by the bronchus being blocked with septic material such as inhaled portions of tonsils, teeth or an impacted foreign body A wedge-shaped area of atelectasis develops and becomes rapidly gangrenous with central liquefaction and a surrounding area of consolidation. There is no drainage and the abscess distends and pyogenic and anaerobic organisms multiply If the abscess ruptures into an adjacent bronchus there is a small preliminary hæmorrhage followed by a discharge of several ounces of foul-stinking pus. This continues unless or until the abscess has obtained free internal drainage.

Signs and Symptoms. The clinical course of an obstructive lung abscess is that the patient becomes febrile and shows immediate signs of toxæmia

The toxæmia is often severe accompanied by early clubbing of the fingers, anæmia and foul breath. If the abscess has not ruptured there is little or no sputum but cough may be persistent. A common site for an abscess is in the apex of the lower lobe or postero-lateral segment of the upper lobe these areas being supplied by bronchi which are dependent when the patient is semi-recumbent or lying flat The sudden rupture of the abscess often heralded by slight hæmoptysis, is dramatic and the volume of pus discharged is so large that patients have at times been drowned in it. After the initial discharge there is some improvement in the general condition but foul pus often containing elastic fibres and evidence of destroyed lung, continues to appear





FIG 36 4 LARGE ABSCESS CAVITY IN THE POSTERIOR AND APICAL PART OF THE RIGHT UPPER LOBE.

A diffuse outline containing a horizontal fluid level is seen. There is gas above the fluid level in the abscess.

Clinically the signs of lung abscess are comparatively few especially if the area involved lies deep to the scapula. There is dullness and absence of breath sounds. Crepitations and râles may be heard but bronchial or cavernous breathing does not occur until the abscess has ruptured. Pleural effusion and empyema are rare unless injudicious aspiration has been attempted. Radiologically the early stages of abscess presents as a diffuse opacity possibly with some central rarefication Later a rounded cavity with a fluid level can be demonstrated and surrounding this there is an area of diffuse opacity It is essential to take lateral skiagrams to obtain accurate localization of the abscess.

Treatment. In the last few years there has been a dramatic change in treatment, intensive use of antibiotics ousting surgery The standard treatment is to give at least two million units of penicillin a day unless the bacteriological examination of the sputum shows it to be insensitive. The response to treatment may be slow but in the course of two or three weeks there is marked clinical improvement and radiologically the abscess becomes smaller If or when, the abscess has ruptured, postural drainage is advisable

and also a careful watch on the patient's general condition A severe secondary anæmia may be encountered In most instances complete resolution occurs but in some chronic cases a ring-like cyst persists and thus may become reinfected at a later date. In such cases, associated bronchiectasis may be found and the question of performing resection will have to be considered if the patient's condition permits. Drainage of an acute lung abscess is now hardly ever indicated

Pulmonary Tuberculosis

The treatment of pulmonary tuberculosis has been radically altered in the past few years by the introduction of the antituberculous agents streptomycin, para-aminosalicylic acid (PAS) and isoniazid. The basis of treatment still depends on rest and sanatorium régime but the resolution produced by chemotherapy now presents a different form of disease for surgical treatment. Cavities and fibrosis are less noticeable and there is an increase in the number of solid or conglomerate foci If after prolonged treatment, these are regarded as being unstable, or if tubercle bacilli are present in the sputum, surgery may be called for

The role of surgery may be likened to that of a demolition squad after an air raid There is little or no place for it in the active forms of the disease, but it can either level destroyed areas or remove them completely so as to render them free from the danger of later accidents. Surgery is not a cure but simply an incident in the course of prolonged treatment. Once an operation has been performed the patient has still to be rehabilitated by treatment at home or in an institution for four to six months

The original principle of surgery was to collapse the lung so that the area of disease was immobilized and healing might take place. To-day excision of the diseased area is popular again thanks to antibiotics which minimize the risks of lighting up the infection

Collapse Therapy The most common form of collapse therapy a few years ago was *artificial pneumothorax*. If the pleural cavity was free from adhesions, injections of air into it collapsed the lung and relaxed the diseased areas. If adhesions presented, a selective collapse, thoracoscopy and *division of adhesions* was performed in many cases. This freed the lung and permitted adequate collapse. *Phrenicectomy* (crushing or avulsing the phrenic nerve) paralyses the diaphragm and reduces the volume of the hemithorax The diaphragm can also be pushed higher into the chest by injecting air into the peritoneal cavity a method called *pneumoperitoneum* The phrenic nerve is reached through a small incision at the base of the neck and is exposed as it lies under the fascia over the scalenus anterior muscle Crushing the nerve leads to paralysis of the hemidiaphragm for four to six months. These operations, though not obsolete, are only rarely performed. More extensive collapse operations still regularly practised include thoracoplasty and extrapleural pneumolysis with " plombage "

Extrapleural pneumolysis This consists in freeing the apex of the lung with its adherent parietal pleura from the inside of the chest wall. The dissection is carried out in the plane of the endothoracic fascia after excision of a short length of rib (usually the third to fifth ribs posteriorly) The large space formed between lung and chest wall is then filled by a " plombe " which takes the form of plastic balls sponges or bags. This keeps the lung compressed and provides a satisfactory collapse. The advantage of the

operation is that there is no deformation of the thoracic cage but the risks of infection of the extrapleural space and extrusion or ulceration of the foreign material has to be considered.



FIG 36 5 ADHESIONS AS SEEN THROUGH A THORACOSCOPE.
The ribs and intercostal muscles shining through the parietal pleura can be identified, with two adhesions, one fibrous and one fleshy

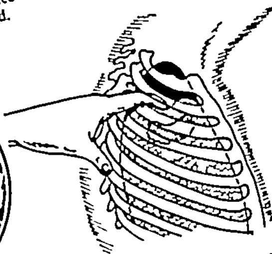


FIG. 36 6. DIAGRAMMATIC ILLUSTRATION OF EXTRAPLEURAL PNEUMOTHORAX.
The small portion of the third rib posteriorly that has been removed is obscured by the finger

Thoracoplasty This has for many years been the major standard collapse operation The upper ribs are removed so that the apex can collapse concentrically towards the hilum, and cavities within the lung are relieved from tension and can retract. The original paravertebral upper thoracoplasty is a two-stage procedure. A long curved incision between the spine and posterior border of the scapula is carried down through the trapezius and rhomboid muscles The scapula is then retracted forwards away from the chest wall and the upper two ribs are removed together with the posterior ends of the third and fourth ribs. The apex of the lung is dissected free in the extrafascial plane (Semb's operation) as far down as the hilum of the lung. The second stage of the operation is performed two weeks later and further rib resection is carried out so that it extends below the level of the disease, usually to the level of the sixth or seventh rib. The underlying lung remains collapsed and is in the best physiological and anatomical position for healing There is a tendency for some degree of scoliosis with the convexity towards the side of operation, but this is minimal if adequate physiotherapy is employed and no deformity is apparent when the patient is clothed. Modifications of the standard thoracoplasty have been introduced recently and the aim of most of these procedures is to preserve the first rib and to fashion a new roof to the depressed lung apex by dividing the second, third and fourth ribs anteriorly as well as posteriorly and fixing them against the mediastinum as an osteoplastic flap The operative mortality of thoracoplasty is less than 2 per cent. and good results are achieved in at least 80 per cent. of patients. The complications of atelectasis and the spread of the tuberculous process have been greatly reduced since the introduction of antibiotics.

Excision Therapy Excision of a focus of disease is now the most commonly practised form of surgery for tuberculosis. The danger of activating the disease has been considerably reduced and resection is eminently suitable for solid areas of disease (which collapse cannot eliminate) and for cavities *and lesions that are not suitable for collapse therapy* It is not necessary with excision to remove every focus of disease but to concentrate on areas which

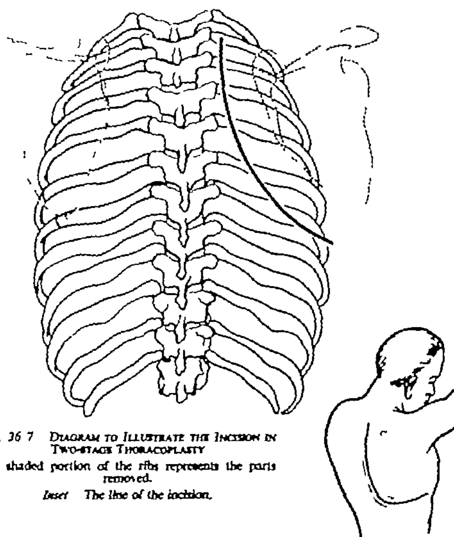


FIG. 36 7 DIAGRAM TO ILLUSTRATE THE INCISION IN TWO-STAGE THORACOPLASTY
The shaded portion of the ribs represents the parts removed.
Inset The line of the incision.

are liable to break down or are "open" and produce tubercle bacilli in the sputum Excision of lung can take the form of wedge resection segmental excision lobectomy and, in severe cases, pneumonectomy

The operation consists of a postero-lateral thoracotomy opening the thorax in the fifth or sixth intercostal space The incision is forcibly opened by a mechanical rib-spreader and the affected area of lung freed from pleural adhesions which may be extensive The bronchus which supplies the segment in which the disease is located is carefully isolated and divided and the corresponding branch of the pulmonary artery secured. The central divided end of the bronchus is carefully sutured and buried in adjacent tissue In the case of a segmental resection *the distal end of the bronchus* is firmly retracted and blunt dissection carried out to identify the intersegmental

planes. The segment strips away leaving an extensive bleeding raw area in which the fan of intersegmental veins is visible. Careful hæmostasis is secured on the raw surfaces and fine sutures are used to control any obvious air leak before they are loosely approximated The chest is drained by two tubes one placed at the bottom of the pleural cavity and the other leading to the apical region so that all air can be removed and the lung

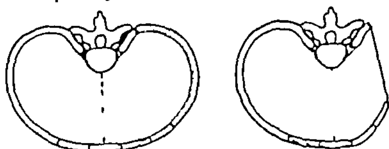


FIG. 36 8. DIAGRAMS TO ILLUSTRATE THE COLLAPSE THAT OCCURS AFTER THORACOPLASTY

quickly re-expanded Suction drainage on the upper tube combats any air leaks that may occur and prevents the lung from falling away from the apex.

When lobectomy or pneumonectomy is required some form of thoracoplasty or phrenicectomy is usually performed to reduce the size of the hemi thorax and prevent over-expansion of the remaining lung tissue. The dangers of the operation, apart from activation of disease, are air-leaks or bronchial fistulæ, which lead to pleural infection and failure of the lung to expand The mortality and results are similar to those of thoracoplasty

Cancer of the Lung

Carcinoma of the bronchus is now the most common form of cancer en countered in men and it is widely held that heavy cigarette smoking is a pre disposing cause. The disease affects men more often than women and though it attacks the middle aged and elderly it can occur in young adults and its insidious and slow character make it difficult to recognize in the early stages. Indeed when there are obvious signs and symptoms the chances are that the growth will be inoperable.

Histologically there are three main types squamous cell carcinoma which affects the main bronchi and is centrally placed adenocarcinoma which tends to be peripheral, and oatcell carcinoma which quickly gives rise to a mass of secondary hilar nodes. The disease does not metastasize unduly quickly apart from a spread to the regional nodes, and on average has a life history of one and a half to two years Unfortunately it is not often diagnosed before it has been present six months to a year

Signs and Symptoms. The clinical features of lung carcinoma can be divided into three main groups. The first when the growth is largely intra pulmonary the second when it involves the pleura and the third when it affects the mediastinum.

Intrapulmonary Tumours may grow as large rounded masses in the lung substance quite silently and only produce symptoms if and when they affect a bronchus Ulceration of a growth leads to cough and hæmoptysis and it is this latter feature which should never be ignored It *may be the only sign* for some months. Obstruction of a bronchus can lead to a variety of signs Atelectasis is commonly seen and obstruction with infection will lead to

chronic pneumonia, bronchiectasis or lung abscess. Cough and pus retention frequently give rise to the mistaken diagnosis of influenza or unresolved pneumonia

Pleural Involvement This gives rise to pain or effusion. The effusion is often blood-stained and indicates extensive invasion of the pleural cavity It is comparatively rare for a growth to invade the chest wall.

Mediastinal Involvement If this occurs, either by the actual growth or involved lymph nodes it produces a variety of bizarre signs. Obstruction of the superior vena cava aphonia due to paralysis of the left vagus or recurrent laryngeal nerve, phrenic nerve paralysis, atrial fibrillation due to extension of growth along the pulmonary veins and dysphagia due to pressure on the œsophagus have all been described If there is pleural or mediastinal invasion the chances of successful treatment are remote.

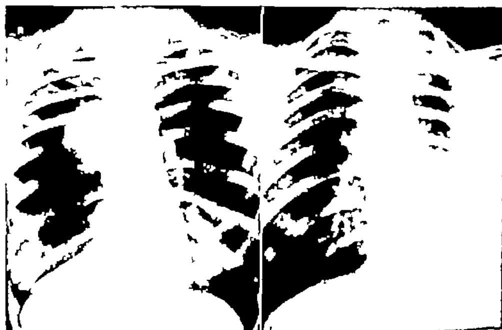


FIG 36 9 CARCINOMA OF THE LUNG. A rounded shadow projects from the right mediastinum. In the lateral view it was seen to occupy the anterior and apical part of the upper lobe. There was lymph node involvement in this case and pneumonectomy was performed.

FIG. 36 10. CARCINOMA OF THE LUNG. There is a large left pleural effusion. Note that the mediastinal shadow is drawn towards the side of the effusion indicating that there is underlying atelectasis of lung.

Diagnosis. Early recognition of lung cancer can be made only by radiography Mass X ray examination and routine radiography is responsible for bringing a proportion of cases to notice some months before any signs or symptoms would occur Any abnormal chest symptom, *e g* increased cough, hæmoptysis, sudden shortness of breath, slow resolution of an attack of influenza in a middle-aged patient requires to be investigated

If there is a radiological shadow whose nature is uncertain, investigations must be pursued until a diagnosis is reached. Bronchoscopy is of the greatest value in the recognition of growths in the larger bronchi and bronchography may reveal a bronchial obstruction out of range of the bronchoscope.

Examination of the sputum for malignant cells is a procedure which in the hands of experts is of considerable importance. In cases of pneumonitis or atelectasis the radiological shadow may be caused by growth or inflammatory change. On subsequent skiagraphic examination this may become smaller but the exclusion of carcinoma cannot be made unless or until a completely normal skiagram is produced The final diagnostic method in cases of doubt is thoracotomy

Treatment. In all cases of neoplasm of the lung the best hope of cure lies in surgery The standard operation is pneumonectomy in which not only the lung but the complete lymphatic drainage is removed. Lobectomy is sometimes undertaken when the patient's general condition would not stand pneumonectomy or when the tumour is sufficiently small and localized to permit of a more limited excision Radiotherapy has some value in the palliative treatment of lung cancer the pressure symptoms on the mediastinum are relieved and the actual tumour may become smaller but where surgery can be attempted radiotherapy must take second place. The proportion of patients suitable for surgery is depressingly small. In less than 15 per cent. of the total number of patients diagnosed is excision possible the extent of the growth and the poor general condition of the patient preclude thoracotomy The mortality of pneumonectomy is less than 10 per cent. and of those who survive operation nearly 30 per cent. live for five years or longer In the absence of lymph node involvement the five-year survival rate reaches 60 per cent.

The assessment of the patient prior to operation includes examination of the respiratory and cardiac function in some detail In addition, breathing exercises and measures designed to improve the general condition should be instituted.

At operation, endotracheal anæsthesia is used and the chest is opened by a long postero-lateral incision with removal of the fifth or sixth rib When the pleural cavity is opened the lung is inspected and the hilum examined for lymph nodes and direct invasion In about one-third of patients, the tumour is found to be inoperable but when it can be removed the lung is freed from adhesions, taking care to remove the parietal pleura if this is fused to the surface of the growth. The hilum of the lung is exposed after incising the mediastinal pleura and opening the pericardium so as to have free access to the pulmonary vessels The main bronchus is isolated and divided close to the bifurcation, so that on suture no blind stump is left. The central end of the bronchus is sutured by interrupted non-absorbable stitches and the distal end retracted to allow full exposure of the lymph nodes and vessels. The main pulmonary artery is next freed and secured by a double stout ligature before division. This leaves the two pulmonary veins, which are ligatured close to the atrium in the same way The order in which the vessels are divided is not important, but if the growth is close to the veins it is wiser to divide them first and so reduce the risk of embolism caused by manipulating a growth which is spreading into a pulmonary vein Before closing the chest the bronchial stump is carefully covered by fascia, pericardium or intercostal muscle in order to reinforce the suture line.

The post-operative course is usually straightforward and the patient is often fit enough to be out of bed forty-eight hours later Accumulation of blood and fluid in the empty thorax may require one or more aspirations, but in the course of two to three weeks fibrin deposit and retraction of the

chest wall and mediastinum start to reduce the size of the space. Final obliteration may take four to six months, at the end of which time the mediastinum is well drawn over towards the operation side.

The dangers of operation lie in pneumonitis or collapse of the remaining lung, particularly in elderly patients with bronchitis and bronchospasm energetic after treatment with coughing and antibiotics minimizes this risk. The other important complication is a bronchial fistula which, if persistent, sooner or later leads to infection of the dead space. If the fistula cannot be closed and the pleural cavity is infected drainage will be required and probably a thoracoplasty at a later date to close the space. The incidence of bronchial fistula is now fortunately low

Lobectomy is carried out as described under bronchiectasis, but with particular attention directed towards removal of all regional lymph nodes.

Hydatid Cysts

Hydatid disease in this country is rare though sporadic cases are found in South Wales. The condition is, however endemic in South America, Australia, Iceland and Mediterranean countries and it is estimated that 40 per cent. of all hydatid cysts occur in the lung.



FIG. 36 11 A HYDATID CYST AFTER REMOVAL.

Clinical Features. Cysts in the lung may be single or multiple and are usually unilocular The layers of the cyst consist of an outer fibrous wall of compressed lung tissue, surrounding an opaque thin ectocyst which encloses the germinal layer or endocyst It is from this inner layer that daughter cysts bud off The contents consist of clear fluid with fine granules of hydatid "sand" which consists of the scolices. If the cyst increases rapidly in size it will cause pressure symptoms cough shortness of breath and hæmoptysis if ulceration into a bronchus is imminent. If the cyst ruptures and discharges its contents into a bronchus most of the fluid and scolices will be coughed up, but there is considerable risk of reinfestation of the lung from any retained endocyst. A ruptured cyst will probably

become infected and behave as a lung abscess The diagnosis is made by the discovery of a rounded or oval shadow or shadows on the skiagram If the cyst has ruptured the Casoni test and complement fixation reaction are positive but with an intact cyst, contrary to general belief these tests are negative.

Treatment The only treatment for hydatid disease is removal of the cyst or cysts at thoracotomy Aspiration should not be employed as the cyst may burst and discharge its contents into the pleural cavity The course of action depends on the size multiplicity and state of the cysts namely whether they are intact or ruptured.

Small Cysts At thoracotomy a small intact cyst will be found to present on the surface of the lung. The thin covering layer of lung tissue should be most carefully incised until the opaque white surface of the cyst is exposed it looks like a hard boiled egg, but is so delicate that it may rupture with finger or swab pressure. Inflation of the lung by the anæsthetist causes the cyst to extrude, when it is received in a container intact This operation of extrusion leaves a raw bed in the lung tissue which has to be carefully obliterated to avoid hæmorrhage and air leaks.

Large Cysts Medium sized or large single cysts should according to some highly experienced South American surgeons, be treated by segmental resection or lobectomy Extrusion is often followed by fibrotic and bronchiectatic changes if the cyst is large, but if there are multiple cysts, resection of lung tissue must be restricted and the extrusion technique adopted. As many as thirty cysts have been removed from one patient.

Infected Cysts An infected cyst, if single, should be treated by resection (usually lobectomy) but prior to operation bronchography is advisable so as to confirm the presence or absence of associated bronchiectatic changes which would influence the extent of the resection.

Tumours of the Pleura and Mediastinum

Tumours of the Pleura. Primary tumours are rare. Endothelioma is occasionally seen and tumours which invade and invaginate the pleura, such as osteoma and sarcoma of ribs, may occur Multiple secondary deposits from cancer of lung, breast, ovary and stomach are much more common and are associated with effusions which are often blood stained. Repeated aspiration of these will be required to relieve pressure symptoms.

Benign Tumours of the Mediastinum. Apart from tumours of the thymus there are a number of benign neoplasms that arise in the mediastinum and whose diagnosis prior to operation is often a matter of conjecture. Many of these are discovered on routine X ray examination of the chest or on mass miniature radiography Usually they present as round or ovoid tumours protruding from the mediastinum into one or other lung field, and can be roughly classified according to whether they lie anteriorly or posteriorly

Neurofibroma. In the posterior mediastinum the most common tumour is a neurofibroma or neurinoma. This tumour arises from the sheath of an intercostal nerve close to the intervertebral foramen and is consequently firmly attached to the vertebral column and the necks of the ribs. There may be an intraspinous projection which can cause neurological symptoms. This is the "dumb-bell" tumour Increase in size will widen the intercostal spaces and lead to pressure erosion of ribs and occasionally to pathological fractures. The treatment is to excise the growth through a transpleural

thoracotomy the pedicle will be found to be firmly fixed and vigorous bleeding from an intercostal artery has to be controlled after detachment. Ten to fifteen per cent. of these tumours recur and appear to be of a low grade sarcomatous character

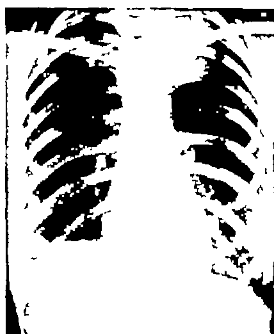


FIG 36 12. NEUROFIBROMA OF THE MEDIASTINUM
A large rounded shadow occupies the left apex. A lateral view showed this to be situated posteriorly

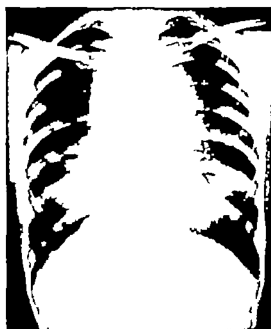




FIG. 36 13 MEDIASTINAL DERMOID.
A large mass in the anterior mediastinum projects into both lung fields causing patchy collapse at both bases. Some of the solid ectodermal elements can be distinguished, particularly in the lateral view

Dermoid Cysts These may be found in the anterior mediastinum They are unilocular containing sebaceous material and ectodermal elements such as hair teeth and even bone with a tendency to calcification in the cyst wall or multilocular and of a more solid character These tumours are firmly attached in the region of the arch of the aorta and may attain enormous size if they do not rupture into a bronchus. The treatment is excision through an anterior or lateral thoracotomy but if removal is not possible for technical reasons the cyst can be sutured to the chest wall after its contents have been evacuated by marsupialization and allowed to discharge externally

Bronchogenic and Enterogenous Cysts These cysts are attached to the trachea, main bronchus or oesophagus, with which they occasionally communicate. They are lined by respiratory or foregut epithelium and often contain altered blood the so-called chocolate cysts Pancreatic, gastric and other tissues are sometimes included. These cysts should be removed not only because of their tendency to increase in size but because of the difficulty of establishing an exact diagnosis between a benign or malignant mass before operation.

Lipomata. These common tumours arise from pericardial or peripleural fat.

Fibromata. In this situation these are associated with cyanosis and clubbing of the fingers. Pleural cysts lymphoma and a host of other rare mediastinal tumours have also been recorded

Tumours of the Ribs. Primary tumours of the ribs are rare, though the chest wall is often the site of swellings which may be due to chronic infective granulomata or to secondary metastatic tumours (hypernephroma thyroid breast and prostatic cancer). True primary tumours include fibrosarcoma, sarcoma and osteoma A recurring type of fibrosarcoma is the most common and produces a fusiform swelling with the greater part of its bulk projecting inwards. Free and wide resection is the only possible remedy as these tumours are not radiosensitive. Ewing s tumour is a highly malignant form of bone growth for which even the most radical form of resection may prove inadequate.

Chapter 37

THE PERIPHERAL VASCULAR SYSTEM

THE ARTERIES

Arterial Injuries

Contusion. Contusion of an artery results from local injury and is more serious when the vessel is already affected by a degenerative process. An artery which is contused may thrombose and this leads to changes in the peripheral vessels distal to the lesion. A good example of this is seen in supracondylar fractures of the humerus, where the brachial artery may be contused and early accurate reduction of the fracture is called for to prevent a Volkmann's ischæmic contracture. Lériche drew attention to the importance of the sympathetic nerve supply maintaining spasm in these cases. If there is not rapid improvement in the circulation a sympatheticolytic drug such as tolazoline should be injected proximally into the vessel. If spasm persists the vessel is exposed any irritating agent removed and papaverine applied to the wall to relax the smooth muscle. A severely damaged section of artery should be doubly ligated and excised.

Partial Rupture. This may lead to a weakening of the arterial wall and later an aneurysm may develop. An example of this may be seen in the axillary artery as a result of damage during attempts at reduction of an old dislocation of the shoulder six to eight weeks after injury.

Complete Rupture. This may lead to severe external hæmorrhage, or if in a confined space, to a condition described as a pulsating hæmatoma. This consists of a firm indurated swelling and expansile pulsation with a thrill and a bruit. Distally the circulation is impaired unless the collateral vessels are plentiful and there may be a varying amount of loss of nerve function, due partly to pressure and also to direct involvement of the nerves. A pulsating hæmatoma usually results in the formation of a false aneurysm which is likely to rupture but may proceed to suppuration or to gangrene.

Penetrating Wounds of Arteries. These injuries may follow stabbing injuries or bullet wounds, but it is surprising how often the blood vessels escape damage owing to their elasticity. When the injury is severe, the immediate treatment is directed to stopping the hæmorrhage by means of a pack or ligatures. If the injury to the vessel is strictly localized it may be possible to repair this by direct suture. In such a repair it is important to control the circulation by means of bulldog or Crile's clamps or the application of a tourniquet. The essentials, which were described by Alexis Carrel fifty years ago, are to secure approximation of the vessel walls by everting stitches so that only the intima comes into relation with the blood within the lumen of the vessel. The suture material should be fine paraffined or waxed silk (5/0 or 6/0) on atraumatic round bodied needles. When the artery is small, thrombosis should be avoided by the use of heparin in the vessel and by its systemic administration thereafter. Anticoagulants such as dicoumarol or phenindione can be given by mouth and in forty-eight to

seventy two hours will take effect so that the injection of heparin becomes no longer necessary The clotting-time or prothrombin-index must be measured daily in the laboratory so that hæmorrhages in other parts of the body do not occur It is wise to cool the limb by exposure to the air in order to lower the metabolic demands of the part until the collateral circulation can take over for in many cases this is likely to be the final result. Occasionally a formal resection of the injured portion of the vessel with end-to-end anastomosis can be undertaken Where the vessel is a large one anticoagulant therapy is not called for because the flow of blood is sufficient to prevent thrombosis. This is especially so in the case of the aorta. Where there is a gap to be filled in a major limb vessel this can be done by employing a vein graft, preserved human artery orlon or polyvinyl sponge prosthesis. Such grafts are of value only where the calibre of the vessel is great and do not succeed in the limbs. A by-pass operation may be successful and is of especial value where it is important to preserve the collateral vessels If gangrene occurs, amputation will be necessary

Arteriovenous Injuries. These follow penetrating wounds where an

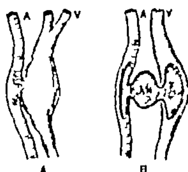


FIG. 37 1 ARTERIOVENOUS COMMUNICATIONS.
A. Aneurysmal varix. B. Varicose aneurysm.

artery and vein are in close proximity and typically occur in the thigh, arm, neck and in the cavernous sinus following skull fractures. One of two conditions may result and these are described as an aneurysmal varix and a varicose aneurysm

Aneurysmal Varix This is produced by a direct communication between an artery and a vein, no dilated passage intervening between the vessels (Fig. 37 1A). The venous walls, being unsuited to withstand arterial pressure, become dilated and are rendered varicose. A pulsating venous tumour results, the dilatation extending for a variable distance above and below the communication. A bruit is heard on auscultation over the lesion and a palpable thrill may be communicated to the veins.

Varicose Aneurysm This differs from the above by the presence of an aneurysmal sac between the two vessels (Fig. 37 1B) The two conditions described above require operative treatment, but it is not urgent and therefore the risk of gangrene is extremely slight as over a matter of months an adequate collateral circulation is likely to develop Pain and increasing size, which indicate a threatened rupture, are indications for operation. Excellent results may be obtained by quadruple ligature, preferably with excision of the mass, unless nerves are too closely attached to it. The larger the shunt and

the nearer it is to the heart, the greater is the strain put upon the latter In extreme cases heart failure may occur

Inflammation and Degeneration of Arteries

Traumatic Arteritis. This may follow both penetrating and non-penetrating wounds and has been referred to above.

Infective Arteritis. This variety results from the involvement of the vessels by sepsis in the neighbouring tissues and when this leads to ulceration of the blood vessels a secondary hæmorrhage occurs.

Embolic Arteritis. This is seen when particulate matter becomes lodged in an artery and this is most likely to occur at places where arteries divide, since the lumen is then markedly reduced Blood rapidly becomes deposited upon the obstruction and the secondary thrombosis which occurs often



FIG. 37 2 ARTERIOGRAM SHOWING BLOCK OF SUPERFICIAL FEMORAL ARTERY FROM LEVEL OF PROFUNDA FEMORIS ARTERY

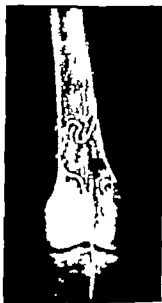


FIG. 37 3 ARTERIOGRAM SHOWING DOUBLE BLOCK OF SUPERFICIAL FEMORAL ARTERY WITH MANY TORTUOUS COLLATERAL VESSELS

overshadows the primary lesion The embolus itself may consist of blood-clot as in the patient with mitral stenosis who releases a piece of thrombus *from the left atrium when fibrillating. It may be infected as in the patient* with bacterial endocarditis. A malignant or tumour embolus occurs typically when a hypernephroma invades the renal vein Fat embolism may complicate a fractured femur and the emboli lodge typically in cerebral and pulmonary vessels. Even parasites such as malaria may act as an embolus. The changes produced will depend upon the nature of the embolus, type of vessel involved and tissues supplied. *When infected it may lead to a mycotic* aneurysm

Acute Endarteritis. This is an inflammatory condition which is usually seen in the aorta and occurs due to the spread of endocarditis directly from the heart. It is often associated with congenital abnormalities of the valves, a patent ductus arteriosus or aortic coarctation

Chronic Endarteritis. *This is typically seen in the condition called*

Buerger's disease or thromboangiitis obliterans *In this there is a patchy internal proliferation affecting not only arteries but also veins and the surrounding tissues.*

Arteriosclerosis. Arteriosclerosis or atherosclerosis is seen typically after middle age and its ætiology is obscure It may be seen in a more severe form when hypertension is present The primary change in the vessel wall is a loss of elastic tissue in the middle and outer coats with hyperplasia of the intima which is associated with deposits of atheroma. Much cholesterol is present but the reasons for its deposition are not known. The late effects depend on the vessel affected and the tissues which it supplies. Thus in the aorta ulceration of *these atheromatous plaques may occur* and form a dissecting aneurysm which may present, when it enlarges rapidly, as an acute abdominal emergency *Smaller vessels may become completely*

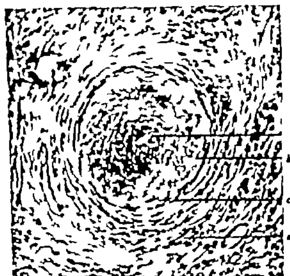


FIG. 37 4 SYPHILITIC ENDARTERITIS IN A SMALL BLOOD VESSEL.
a. Recanalisation. *b.* Intima. *c.* Muscle. *d.* Periarteritis.

occluded and this is especially so in the brain (cerebral thrombosis) and the myocardium (coronary thrombosis). In the limbs, arteriosclerosis is the commonest cause of senile gangrene and is particularly common in diabetics. In hypercholesterolæmia, atheromatous plaques may be seen in the vessels without the presence of other degenerative changes.

Syphilitic Endarteritis. This was formerly a common cause of arterial disease but is now only rarely seen Syphilis produces most of its changes by an endarteritis which occludes the lumen of the arterioles and smaller arteries (Fig. 37 4) The vessels show an infiltration of the walls by plasma cells and lymphocytes and the larger vessels are only indirectly involved *in so far as the smaller arterioles within their walls are affected* Thus aortic aneurysms develop because the nutrition of the wall of the artery is impaired by the occlusion of the vasa vasorum. Syphilitic aneurysms occur typically in the ascending aorta and its arch whereas those due to arteriosclerosis are far more common in the descending aorta and especially in its abdominal portion.

Tuberculous Endarteritis. This is a similar chronic condition to that

described above and the obliteration of arterioles is a factor contributing to caseation.

Temporal Arteritis. This is heralded by an acute febrile disease with sweating, unilateral headache and reddening of the affected skin. Excision of a segment of the thickened, tortuous temporal artery relieves the pain. All coats of the artery are affected especially the media which usually shows giant cells.

***Medial Degeneration* or *Mönckeberg's Sclerosis*.** This is seen in elderly people and takes the form of deposition of lime salts in the muscle coat of the artery The vessels become rigid and are readily recognized on a skiagram (Fig. 37 5). The condition is often complicated by arteriosclerosis



FIG. 37 5. SKIAGRAM SHOWING CALCIFICATION OF ARTERIES IN MÖNCKEBERG'S SCLEROSIS.

Rarely calcification is seen in the peripheral vessels of young people when it may be associated with hyperparathyroidism or the administration of excessive doses of calciferol.

Amyloid Degeneration may be seen in the wall of an artery but is only a local manifestation of generalized amyloidosis.

Polyarteritis Nodosa. *This is accompanied by generalized phenomena* such as fever muscle pains, anorexia and tachycardia. Small arteries are usually affected presenting nodular swellings with necrosis of media and intima and infiltration with polymorphs and eosinophils. The symptoms are protean but of particular importance to the surgeon is the fact that the small aneurysms may rupture to produce intraperitoneal or intrapleural hæmorrhage. Diagnosis is confirmed by muscle biopsy and treatment in the form of cortisone relieves most of the symptoms.

The result of arterial inflammation or degeneration is that the *lumen of*

the vessel becomes obstructed and thrombosis may take place. Alternatively the wall may become weakened leading either to an aneurysm or actual rupture. Distal to the lesion the blood supply is impaired and if an end artery is involved there is loss of function, e g gangrene of the toes, hemiplegia or an infarct of an organ such as the kidney or lung

Aneurysm

An aneurysm is a sac filled with fluid or coagulated blood communicating with the interior of an artery the walls of which have usually become dilated The main factor in the ætiology is a weakening of the arterial wall which may be due to arteriosclerosis the effects of trauma or syphilis (Fig. 37 6)



FIG. 37 6. A DOUBLE SYPHILITIC ANEURYSM OF THE BRACHIAL ARTERY

The degenerative lesions of arteries, such as arteriosclerosis, may lead to a *dissecting* aneurysm due to a break in the intima. A *mycotic* aneurysm results from an infected embolus lodging in the vessel wall and thus may occur in young as well as old people. Hypertension is only of importance where the vessel wall is already diseased and therefore capable of distension.

Names are also given to aneurysms to describe their appearance. For example, a cirsoid aneurysm is one in which there is a collection of tortuous arteries as shown in Fig. 37 7

Structure of Aneurysms. The sac consists at first of all or most of the original coats of the vessel, but as the aneurysm dilates, the original structure is gradually replaced by fibrous tissue with a condensation of the surrounding tissues externally and a layer of laminated fibrin replacing the endothelium internally The contents of the aneurysm depend on its character age and size. While small it retains a complete endothelial lining and the contents are fluid blood as it grows, particularly if it is saccular fibrin is deposited in layers and these may gradually encroach on the cavity and in rare circumstances lead to a spontaneous cure. The older laminæ are dry and



FIG. 37 7 CIRSOID ANEURYSM OF HAND AND FOREARM.

yellowish white and the more recent ones red and friable Calcium deposits may occur and these may be seen in skiagrams.

The three common types of aneurysm are fusiform saccular and dissecting (Fig. 37 8).

Fusiform Aneurysm This is one in which the whole lumen of the vessel is more or less equally expanded so that the swelling is a tubular aneurysmal dilation. It results from widespread disease in a large vessel, usually the aorta. *The intima is intact and fibrin deposits do not therefore occur* but the media is thinned and atrophied while there is inflammatory thickening of the adventitia. The progress of the lesion is slow and if it occurs in the thoracic aorta it may attain enormous dimensions and produce symptoms through pressure on other structures. Natural cure is excessively rare and the treatment is surgical excision if this is feasible.

Saccular Aneurysm This is the distension of a localized part of the vessel wall due to a circumscribed area of weakening. It communicates with the interior of the artery by an opening of variable size Traumatic aneurysms, whether due to partial division of the vessel wall or to later stretching of fibrous tissue, are of this type and they are therefore most

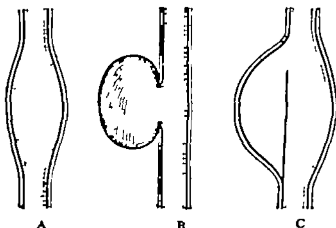


FIG. 37 8. TYPES OF ANEURYSM.
A. Fusiform. B. Saccular C. Dissecting.

commonly seen in the extremities The inner and middle coats can usually be traced as far as the mouth of the sac but at this point they disappear the wall consists of fibrous tissue which is lined with laminated blood clot. The progress of a saccular aneurysm is much more rapid than the fusiform type and may result in rupture although a natural cure by thrombosis occasionally results.

Dissecting Aneurysm This is one in which the blood passes through a rent in the intima and stripping this up may travel long distances along the artery the line of cleavage being the media The ætiology is usually atheroma and the first part of the aorta is one of the commonest sites. The recent vogue for lumbar aortography has produced a number of examples with excellent radiographic proof of their production, the needle having been thrust right across the lumen of the aorta and its point lying just deep to the intima in the opposite wall The blood may remain limited within this cavity for some time or it may either rupture outwards or inwards. In the latter case the blood vessel becomes double barrelled and the condition is often arrested

Symptoms and Signs of Aneurysms. These are conveniently divided into two groups, intrinsic and extrinsic.

Intrinsic A tumour pulsating synchronously with the heart's beat, is present in the course of a vessel The pulsations are expansile in character the whole tumour increasing in size at each systole and evenly in all directions so that if the tumour is grasped the fingers are separated. A thrill can often be felt as the blood enters the sac at each heart beat. If the entering vessel is compressed, the pulsation ceases and the tumour diminishes in size and becomes softer this is more marked in fusiform than in saccular aneurysms. The application of pressure to the sac itself while the ingoing vessel is compressed, may still further diminish its size On removing the pressure the swelling regains its previous dimensions, in a number of beats usually not more than two or three. Pressure on the vessel distal to the sac makes it more tense and the pulsation more marked. Auscultation reveals a bruit of variable character usually loud, harsh and systolic, but sometimes quiet and musical.

Extrinsic The pressure of an aneurysm on the structures in its vicinity lead to a variety of signs at the same time as the distal circulation is progressively impaired. The pulse distal to the aneurysm is diminished and delayed. Smaller vessels engaged in establishing a collateral circulation may be compressed and the blood supply to the tissues impaired. Pressure on the accompanying vein or veins may lead to thrombosis with distal congestion and œdema. Pressure on nerves causes pain, spasm or paralysis. Muscles are displaced distorted and attenuated. Bones are eroded as evidenced by a constant boring pain and spontaneous fracture may result. Joints may be pressed upon and eventually disorganized. Bone is much more liable to be eroded than cartilage which is more elastic. Where the vertebral column is encroached upon by an aneurysm, the bones are always destroyed more than the intervertebral discs (Fig. 37 9) The trachea and to a lesser degree the œsophagus are displaced and may be constricted or even ulcerated.

If the aneurysm is large and near to the heart a certain amount of compensatory hypertrophy especially of the left ventricle, occurs. Laminated blood clot is laid down in the aneurysm and may lead to spontaneous cure or if a portion becomes dislodged and passes on as an embolus, to gangrene

Ligation Ligation of the vessel entering or leaving an aneurysm is of a special historic interest and is still occasionally useful where an aneurysm is inaccessible or cannot be excised Compression of an artery may be of value in deciding whether it is safe to ligate it, as for example in the case of the internal carotid. Fig. 37 10 indicates the classical methods of ligation for aneurysms. After ligation pulsation may return for a day or two and then disappear but if it reappears some days after ligation, the hope of cure is considerably lessened

Introduction of Foreign Bodies Colt's method is the introduction of steel wire by means of a trocar and cannula into an aortic aneurysm where

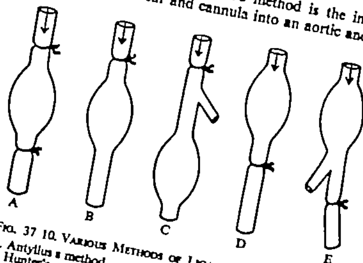


FIG. 37 10. VARIOUS METHODS OF LIGATION OF ANEURYSMS.
A. Antyllus's method. B. Anel's method.
C. Hunter's method. D Brasdor's method.
E. Wardrop's method.

it coils up The wire encourages clotting and in addition an electric current may be passed through it in order to produce thrombosis

Aneurysms of Particular Arteries

Thoracic Aorta. Aneurysms of this vessel are usually due to syphilis and are commonly of the fusiform type, especially in the early stages. Sacculation may occur later and saccular aneurysms are occasionally seen in the arch or in vessels leaving the aorta The signs and symptoms vary with the site and are conveniently divided into the ascending, transverse and descending parts of the arch.

The Ascending Aorta In this portion of the arch the swelling rare reaches a great size, especially if it is intrapericardial, the sac usually rup turing before pressure signs are evident.

The Transverse Aorta Here the symptoms vary with the direction taken by the enlargement. Projection upwards leads to a pulsating tumour at the sternal notch and pressure on the great veins. Extension anteriorly leads to a large pulsating tumour at the right of the sternum with eventual erosion of ribs and cartilages, a process which is associated with severe pain If the enlargement takes place backwards or downwards within the concavity of the arch dyspnœa and dysphagia are produced due to pressure on trachea œsophagus and pulmonary vessels. Pressure on the left recurrent laryngeal nerve produces hoarseness and choking attacks with a distinctive brassy

cough the so-called tussis anserina Similar damage to the sympathetic chain leads to a Horner's syndrome A "tracheal tug" may be elicited due to the attachment of the pretracheal fascia to the pericardium X ray screening is valuable as the aneurysm can be seen to expand with each heart beat

The Descending Aorta Aneurysms may reach a large size and tend to project posteriorly to the left of the vertebral column A prominent symptom is pain due to erosion of ribs and vertebræ but dysphagia is also common and a barium swallow with X ray screening is a useful diagnostic aid

Treatment in the past has been confined to the introduction of Colt's wire although occasionally a saccular aneurysm is found to be suitable for excision More recently various attempts have been made to excise such aneurysms and insert a graft, usually made of polyvinyl sponge. A temporary by pass graft is inserted in the first place or alternatively anæsthesia is combined with hypothermia

Innominate Artery Aneurysm of this vessel is usually of the fusiform or tubular variety and often associated with a similar lesion of the aorta. It presents behind the right sternoclavicular joint The pulse is diminished in right radial and temporal arteries and there may be brawny œdema of the right arm and of the face from pressure on the right innominate vein. The left side may also be affected Involvement of the brachial plexus gives rise to pain and pressure on the cervical sympathetic leads to a Horner's syndrome. Dyspnœa is due to pressure on the trachea and the recurrent laryngeal nerve may be involved The only treatment usually is distal ligation and this should be incomplete.

Common Carotid Artery Aneurysm of this artery occurs in the upper part of its course near the bifurcation and occurs more commonly on the right side. The intrinsic signs of an aneurysm are present and pressure on the sympathetic chain may lead to a Horner's syndrome Differentiation of the types of aneurysm seen at the root of the neck and the vessels involved is difficult and angiography is helpful The carotid arteries in older women are occasionally extremely tortuous and may be confused with aneurysms. Treatment is by ligature which should be done proximally The brain then receives its blood supply *via* the external carotid through collaterals to the internal carotid Alternatively the vessel may be grafted under hypothermia.

External Carotid Artery Aneurysm of this vessel is a rarity It may produce wasting of one half of the tongue due to pressure on the hypoglossal nerve.

Internal Carotid Artery Aneurysm of this artery produces a symptom complex similar to aneurysm of the common carotid artery Treatment depends on the age of the patient. After the age of forty ligation of the common carotid artery and more especially of the internal carotid carries the risk of cerebral damage. The risk can be estimated by temporarily occluding the vessel under local analgesia or by noting the electroencephalographic changes when the vessel is temporarily compressed under general anæsthesia. Ideally the vessel should be replaced by a graft using hypothermia.

Intracranial Aneurysms. Apart from the multiple congenital "berry" aneurysms which occur at the bifurcation of vessels, these occur more commonly on the internal carotid and its branches than on the vertebral arteries. The signs are those due to pressure together with a persistent throbbing headache, and a bruit which can be detected by auscultating the skull.

Treatment is by ligation of the internal carotid or it may be possible to apply a silver clip directly to the base of the aneurysm (Chapter 23).

Orbital Aneurysm. This condition, also known as pulsating exophthalmos, is due to (*a*) a congenital cavernous hæmangioma, (*b*) traumatic communication between the cavernous sinus and the carotid artery (aneurysm of the ophthalmic artery or (*d*) thrombosis of the cavernous sinu The patient complains of pain and increased tension in the eye which forced forward and may show chemosis. If untreated the condition often proceeds to blindness in that eye. Treatment is ligation of the internal carotid

Subclavian Artery Aneurysm of this vessel produces a pulsatile swelling behind the clavicle and by irritation of the phrenic nerve may give rise to hiccough Treatment is by ligation of the artery proximal to the aneurysm and is best carried out after division of the clavicle

Axillary Artery Aneurysm of this artery follows upon trauma as for example the over-energetic reduction of a dislocated shoulder Proximal ligation is the operation of choice.

Abdominal Aorta. Aneurysms of the abdominal aorta must be differentiated from tumours overlying the aorta which transmit pulsation, such as carcinoma of the pancreas, ovarian cysts or fæcal masses. They must be distinguished also from aneurysms of the splenic, renal or hepatic arteries, all of which are amenable to ligation. Treatment of an abdominal aneurysm is by its excision and replacement by a graft if this is possible. Where the aneurysm involves the origin of the renal arteries this will not usually be possible, although by using hypothermia it can occasionally be achieved.

Iliac Artery Aneurysms of this vessel are readily diagnosed because they can be palpated. Proximal ligation may be satisfactory or alternatively the aneurysm is excised and a graft inserted

Femoral Artery Aneurysms of this artery are usually of the fusiform variety Since the femoral artery is a continuation of the external iliac artery ligature of the latter may be indicated. Aneurysms in this site are amenable to excision and replacement with preserved arterial grafts.

Popliteal Artery Aneurysm of this vessel occurs almost invariably in men and can increase in size fairly rapidly Following rupture, gangrene threatens so that treatment should be carried out whenever such an aneurysm is diagnosed. The operation is proximal ligation or excision of the aneurysmal sac, a lumbar sympathectomy being carried out at the same time to improve the collateral circulation. Aneurysm of the popliteal artery can also be excised the two ends being joined by a graft of freeze-dried artery or polyvinyl sponge prosthesis.

Arterial Ligature

The operation of ligaturing an artery may be performed for primary or secondary hæmorrhage, for aneurysm, or as a preliminary to some other procedure which would otherwise be difficult owing to hæmorrhage In addition a vessel may require exposure for embolectomy arteriography or for the relief of vasospasm. A knowledge of the anatomy of the main arteries of the body and how they may be exposed is of value in many branches of surgery

General Principles With large arteries it is usually convenient to make

an incision in the adventitia and then pass an aneurysm needle round the vessel thus avoiding the surrounding structures With smaller arteries the venæ comites can be safely included in the same ligature. Reef knots should be used for all ligatures and thread silk or chromic catgut is a suitable material. The patient need not be kept in bed for more than a day after a major vessel has been tied so long as strenuous movement of the affected part is not allowed to take place Where an extremity is involved it is wise to cool the part locally Collateral circulation can be encouraged by reflex dilatation from heating a remote part of the body Brief notes about ligature of the main vessels are given below

The exposure of particular arteries will now be described The great vessels of the heart are considered in Chapter 38

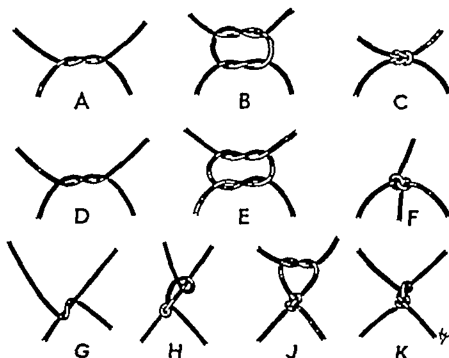


FIG. 37 11
A, B, C REEF KNOT D E, F GRANNY KNOT G H J K SURGEON'S KNOT.

Innominate Artery This is exposed by division of the inner end of the clavicle and the manubrium sterni. A flap of muscle and bone can then be turned upwards which gives good exposure of the artery

Common Carotid Artery The position of the vessel is indicated by a line drawn from the sternoclavicular joint to a point mid-way between the angle of the jaw and the tip of the mastoid process. The bifurcation is usually described as being on a level with the upper border of the thyroid cartilage but is often higher The artery may be tied either above or below the level of the omohyoid. For ligature above the omohyoid the chin is raised and the head turned to the opposite side. An incision is made at the level of the cricoid cartilage and the artery found in the angle between the omohyoid and sternomastoid muscles. By opening its sheath the vagus nerve can be avoided Ligature below the omohyoid is a more difficult dissection and an incision in the line of the vessel gives the best exposure.

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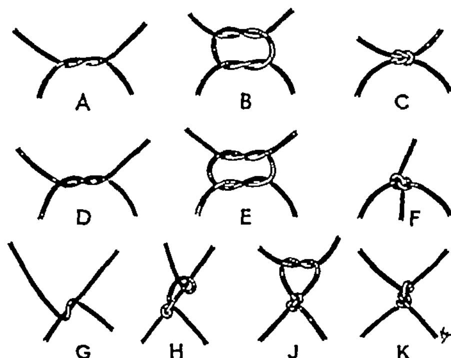


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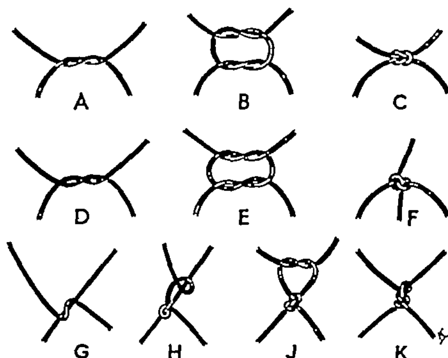


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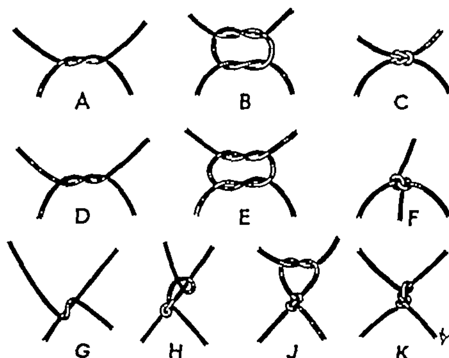


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Internal Carotid Artery The incision is centred opposite the greater cornu of the hyoid bone and the vessel ligated as it disappears beneath the posterior belly of the digastric muscle When setting out to ligate either the external or internal carotid arteries it is essential to display fully the bifurcation of the common carotid artery so that there is no doubt as to the identity of each vessel

External Carotid Artery This is usually ligated between its superior thyroid and lingual branches, care being taken to avoid the hypoglossal nerve This operation is often performed as a preliminary to extensive operations on the tongue or jaws.

Subclavian Artery This is usually tied in its third part. The patient's



FIG 37 12. INCISIONS FOR EXPOSURE OF VESSELS IN THE UPPER LIMB.

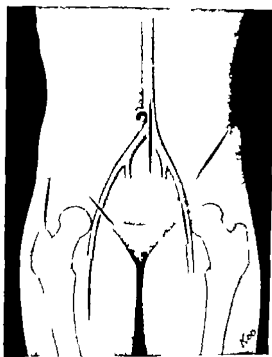


FIG 37 13 RELATION OF ILIAC VESSELS TO SURFACE MARKINGS AND INCISIONS FOR EXPOSURE.

head is turned to the opposite side and the arm pulled well down An incision is made over the clavicle with the skin pulled down so that it subsequently retracts upwards. Care is taken to avoid the transverse cervical and transverse scapular arteries and the ligature must be kept carefully away from the brachial plexus. In a fat and thickset patient better access is given by dividing the middle of the clavicle

Axillary Artery This can be tied in its first or third part. A curved incision is made below the clavicle from the coracoid process to the sternoclavicular joint. The pectoralis major muscle is divided and the artery ligated the operator being careful to avoid the cords of the brachial plexus. The approach to the third part is easier and is made with the arm widely abducted. An incision is made parallel to the vessel which is superficial at this point.

The remaining vessels of the upper limb may require exposure but this

is largely an anatomical exercise since a tourniquet can be employed (Fig 37 12)

Common Iliac Artery The aorta terminates over the fourth lumbar vertebra at a point indicated on the skin just below and to the left of the umbilicus. The common iliac artery may require ligation for a very large iliac aneurysm. A transperitoneal approach is employed, care being taken to avoid the ureter

Internal Iliac Artery This has a short course and may require operation for aneurysm in the buttock or for a primary or secondary hæmorrhage in that area. An abdominal approach is employed as for the common iliac artery The artery or its posterior branch can usefully be ligated on both sides before extensive pelvic operations.

External Iliac Artery This is indicated by the lower 7–10 cm. (3 to 4 inches) of a line drawn from the termination of the aorta to a point mid-way between the anterior superior iliac spine and the symphysis pubis. The artery is approached extraperitoneally using a modification of Abernethy s method, dividing the muscles and pushing the peritoneum inwards.

Femoral Artery Proximal to the profunda femoris branch the femoral artery is exposed by a vertical incision which extends equally above and below the inguinal ligament The artery is rarely tied, except as a preliminary to amputation through the hip joint.

Distal to the profunda branch the femoral artery lies under a line drawn from the mid point of the inguinal ligament to the adductor tubercle, the thigh being flexed abducted and everted The vessel may be tied (*a*), at the apex of Scarpa s triangle, or (*b*) in the femoral canal.

(*a*) An incision is made parallel to the vessel a hand s breadth below the inguinal ligament the inner border of the sartorius muscle is defined and drawn outwards and the vessel is then exposed and tied

(*b*) An incision is made in the mid-third of the thigh in the line of the artery This time the outer border of the sartorius muscle is defined and retracted inwards and backwards. The aponeurotic covering stretching between the adductor longus and vastus medialis muscles is exposed and the sheath of the artery is incised so that when the aneurysm needle is passed around it the accompanying nerve is not picked up.

Popliteal Artery The best approach is from behind with the patient lying prone. Formal ligature is seldom required but exposure of the popliteal artery may be called for in cases of aneurysm and of arterial spasm due to fracture or other injury It should be remembered that the femoral vein, which lies medial to the artery above, passes deep to it in the femoral canal and in the popliteal fossa is superficial to the artery but adherent to it. The medial popliteal nerve crosses both vessels from without inwards and is therefore the first structure encountered in the popliteal dissection.

Posterior Tibial Artery This vessel may be exposed in its upper or lower part. The incision starts 5 cm. (2 inches) below the flexion fold of the knee between the two heads of the gastrocnemius. It passes downwards keeping close to the medial belly and ends just behind the medial malleolus at the ankle. The areolar tissue medial to the Achilles tendon is opened up and a finger passed upwards deep to the soleus muscle. The latter is then incised and the artery is seen lying medial to the posterior tibial nerve.

Anterior Tibial Artery This artery is exposed by a vertical incision passing down from the head of the fibula and keeping to the outer border of

the tibialis anterior muscle. The wound is deepened between the tibialis anterior and extensor muscles to expose the artery lying on the interosseous membrane *close to its attachment to the tibia.*

THE VEINS

Varicose Veins

The term varicose is applied to veins which are *dilated* and *tortuous* they are typically seen in the legs, but may also be seen in the lower



FIG. 37 14 SEVERE VARICOSE VEINS WITH A SAPHENA VARIX.

œsophagus in portal hypertension in the lower rectum when they are usually called *piles or hæmorrhoids*, and *in the pampiniform plexus* when they constitute a varicocele. We are concerned here, however only with those seen in the lower extremity

Pathology and Ætiology There would appear to be two main factors which are responsible for the development of varicose veins. The first is a congenital abnormality of the actual structure of the vein or its valves, which accounts for the fact that varicose veins are frequently a familial condition. The second factor is that of increased intravenous pressure, *especially where this is combined with inadequate support by the surrounding* tissues. Thus, pregnancy leads to pressure on the pelvic veins and increased pressure on the venous system in the legs and, similarly occupations which

improved by having the superficial veins stripped or tied and therefore the test does not really serve a useful purpose except in unusual circumstances.

The test is done by placing a tourniquet lightly round the upper part of the thigh tight enough to prevent any blood passing up or down the veins. The patient is then asked to walk quickly for a few minutes. If communicating and deep veins are normal, the blood in the varicose veins drains into the deeper veins and the varicose ones appear to shrink. If however the deep veins are not able to carry away the blood then the varicose veins become even more prominent and distended. The importance of the test is probably to show up the rare patient who suffers severe pain when trying to walk with a light tourniquet round the thigh and these should not be subjected to division of the varicose veins.

Another way of applying the test is by the use of a rubber bandage (Fig. 37 16). If there is a blockage of the deep veins the superficial veins become even more prominent.

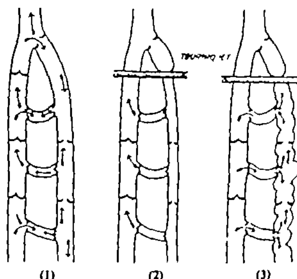


Fig. 37 15 Perthes's Test

(1) The circulation of blood through the thigh (2) the results of the application of a tourniquet when the deep veins are normal and (3) when the deep veins are blocked

A variation of Perthes's test is the triple tourniquet test in which by placing a series of tight bands round the leg, it is possible to locate which communicating veins are functioning between the superficial and deep systems. Since these communicating veins are often the cause of failure to obtain a good result after treating varicose veins, their identification may be of importance.

Cruveilhier's Sign This consists of a hum which can be heard with a stethoscope placed over the upper part of the saphenous vein. It is best elicited when a saphena varix is present, this is a collection of tortuous varicose veins found overlying the saphenous opening in the thigh.

Kelly's Sign This test may indicate that the valve guarding the opening of the long saphenous vein is incompetent. The patient is examined standing and two fingers are placed over the upper part of the saphenous vein. The patient is asked to cough and if the valve is incompetent an expansile impulse and thrill is felt by the examining fingers.

Treatment *Operative* The most valuable method available at the present time for treating varicose veins is the operation of stripping An integral part of this operation is a high ligation of the long saphenous vein so that the proximal ligature lies flush with the femoral vein All the tributaries of the saphenous vein within the last five centimetres should be doubly ligated and divided and then a flexible metal stripper is introduced into the vein at the level of the ankle and threaded up to the thigh The stripper is

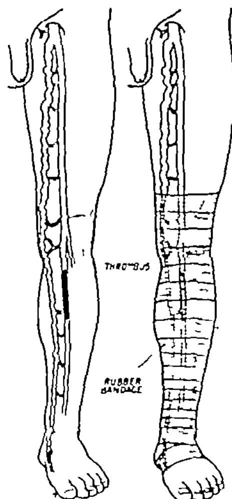


FIG. 37 16. VARICOSE VEINS RESULTING FROM A THROMBOSIS OF THE DEEP FEMORAL VEIN AND THE EFFECTS OF THE APPLICATION OF A RUBBER BANDAGE. (PERTHES'S TEST.)

then pulled through, thereby tearing out the vein, usually inside out, and a fair amount of bleeding results. Firm dressings are therefore applied throughout the leg and thigh as the stripper is withdrawn and the use of properly applied crêpe bandages reduces bleeding and reaction to a minimum The wounds in the ankle and at the groin are then carefully sutured and sterile dressings applied. The patient is allowed out of bed the same day and is encouraged to walk thereafter The pressure bandages are kept on for three or four days and the stitches removed after a week. A separate incision may be used to tie the short saphenous vein in the popliteal space and this vein also may be removed by stripping, if it is considered necessary

Small varicose tributaries may be doubly tied and divided through short incisions, or the veins may be avulsed after grasping them firmly with forceps.

Injection Therapy. The injection of sclerosing fluids into veins has a limited use in that it will cause clotting in a short segment of vein which will be followed by fibrosis and in some cases apparent disappearance of the venous radical. Many substances have been used for this, among them sodium morrhuate, quinine and urethane, concentrated sodium chloride solution and concentrated glucose solution. It is best to insert the needle with the patient standing and then have him sit down, injecting the fluid with the vein as collapsed as possible. A small dressing should be applied and fixed in place with adhesive strapping or a crêpe bandage. Sclerosing solutions are of most use when they are employed in conjunction with

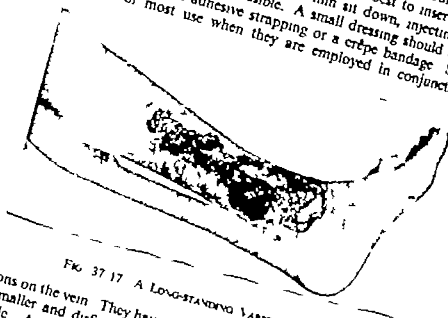


FIG. 37.17. A LONG-STANDING VARICOSE ULCER.

operations on the vein. They have an especial place in the cosmetic treatment of the smaller and disfiguring varicose veins which occur around the foot and ankle. A serious objection to the use of sclerosing solutions is the possibility that the fluid after injection will pass through a communicating vein into one of the deep veins of the leg and cause a block at that site. This is best avoided by never employing more than 2.5 ml of sclerosant and always using the empty vein technique.

Varicose Ulceration. Varicose veins are often complicated by dermatitis and pigmentation of the skin over the lower third of the leg, especially on its inner aspect. The most important complication of varicose veins, however, is a varicose ulcer, a condition which is very commonly seen to-day and which leads to much disability. A long-standing varicose ulcer may eventually become malignant. This condition, which is illustrated on page 58, is referred to as a Marjolin's ulcer and is a squamous-celled carcinoma.

A varicose ulcer is usually found on the inner aspect of the lower leg, a little above the medial malleolus. It is quite commonly bilateral. Such ulcers are much commoner in women than men and are usually seen after middle age. Often the patient states that she has knocked the limb and dates the ulcer from that time. About a third of the patients give a history of having had a "white leg" following a pregnancy and there is close correlation between a deep vein thrombosis and the subsequent development of a varicose ulcer.

Treatment This is a difficult problem because so long as the patient spends much of the day standing or walking it is unlikely that the ulcer will heal unless extremely *firmly supported* Treatment in the first place should be directed at treating any varicose veins which are present and this will mean an operation in the groin and stripping of any varicose radicals. Occasionally an obvious "feeder" is apparently responsible for a varicose ulcer and treating this vein will help considerably in leading to *the healing* of the lesion If the ulcer is grossly infected and contains much dead tissue, it should be cleansed for a few days with hypochlorite solution but the use of antibiotics is best avoided as the tissue rapidly becomes sensitive to them As soon as a fairly healthy looking granulating surface has been obtained the ideal treatment is to use a firm bandage containing some soothing substance such as Unna's paste, or a mixture of zinc oxide and ichthyol The impregnated bandage is applied firmly from the base of the toes up to the knee. Healing is slow and the new epithelium will remain particularly liable to trauma so that the ulcer area is always prone to break down again An elastic net stocking may be the most effective support for the leg. Some *of these varicose ulcers are said to be caused by communicating valves just* above the ankle joint, so called incompetent ankle vein blow-outs. If conservative measures fail to produce healing, a flap including all tissues down to the deep fascia is raised above the ankle and these communicating veins sought for tied and divided

Thrombophlebitis and Phlebothrombosis

Thrombophlebitis is an acute inflammation of the wall of a vein together with the surrounding tissues and especially the lymphatics, with thrombosis of the blood within the lumen of the vessel. The general signs and symptoms are usually severe with local heat, redness, tenderness, fever and a high swinging temperature. It is convenient to distinguish from this particular clinical picture the other condition of phlebothrombosis in which the important factor is the thrombosis within the lumen of the vein whereas the inflammatory or phlebitic part of the condition is relatively mild or may even pass unnoticed The two conditions cannot be sharply distinguished from each other one merging insensibly into the other but it is convenient to distinguish that group in which the inflammatory aspect is the presenting one from those in which thrombosis is the major event. One important *practical difference between the two conditions is that in thrombophlebitis* the clot is firmly adherent to the vein wall whereas in phlebothrombosis the clot is non-adherent and therefore embolism is likely

Causes. The causes of thrombophlebitis are injury and infection. It *is often produced by the indwelling blood transfusion* needle or polythene tubing used for infusions. Phlebothrombosis can be caused in like manner but is often seen in patients who are lying in bed, especially if they are supported in Fowler's position with a pillow under the knees. It is common after operations when there is probably stasis of the leg veins and it is also seen commonly in the puerperium or following a hæmorrhage In the latter conditions there is an increase in the platelet count and a definite tendency to coagulation of the blood

Signs and Symptoms. The signs and symptoms of thrombophlebitis are at once evident with a red swollen painful area usually in one of the limbs. Phlebothrombosis on the other hand is insidious in its onset and may

often pass unnoticed, a pulmonary embolus first drawing attention to it. The symptoms may consist of mild stiffness and pain in the sole of the foot or calf of the leg and there is pain on passively dorsiflexing the ankle joint (Homan's sign) There is often a spiking of the temperature and a little tachycardia. Careful palpation between the two heads of the gastrocnemius may elicit tenderness or there may be a localized tender area in the sole of the foot. When redness and œdema appear it usually indicates that the process has been present for some days.

Complications The main complication of this condition is embolism. A clot may break off within the femoral or iliac veins and be swept up to the heart and then, if large, will be arrested at the bifurcation of the pulmonary artery producing death almost instantaneously Smaller clots may be arrested in the lung fields or in various sites in the body Thrombophlebitis has a great tendency to recur

Treatment. It is important to stress prophylaxis in the prevention of thrombophlebitis and phlebothrombosis. This means scrupulous attendance to detail in setting up all transfusions or in performing operations upon peripheral veins. It means also that all patients who have undergone operation must have exercises to keep the venous circulation in the legs moving. They should never have any hard or restrictive structure put behind the knees and should be encouraged to get out of bed and walk on the earliest possible occasion Careful replacement of lost water and electrolytes is likewise important and a careful watch should be kept for the earliest signs of tenderness in the feet of calves.

Anticoagulant Therapy As soon as it is clear that thrombosis is taking place the patient should be given heparin intravenously An injection of 75 to 100 mg. is given, followed by 50 mg. every six hours thereafter It is convenient to use a small indwelling intravenous needle with a rubber diaphragm so that the injections can be given without disturbing the patient during the night. At the same time as the heparin is started intravenously an anticoagulant is given by mouth Ethyl biscoumacetate (Tromexan) or phenindione, 50 to 100 mg. daily is given and within three days will have taken such effect that the heparin can be discontinued Careful watch should be made that the anticoagulants are not pushed to such a level that spontaneous hæmorrhages occur For this purpose the prothrombin level should be determined in the laboratory each day it should be kept about 30 per cent. of normal with a prothrombin time of thirty-five to forty seconds. As soon as possible the patient is got out of bed and when able to spend most of his waking hours out of bed it is safe to stop the anticoagulant therapy Where, in spite of such treatment, further emboli occur the possibility of dividing the saphenous veins, femoral veins, or inferior vena cava may be considered. The operation usually consists of a simple ligation of the femoral vein under local analgesia and should always be carried out bilaterally since it is usually the limb in which there are no signs from which the thrombus has broken away

The acute form of thrombophlebitis is possibly less dangerous from the fact that it is less likely to produce pulmonary embolism but it is certainly much more incapacitating in the changes it produces in the legs. Often the thrombophlebitis is so severe as to cause a transient arterial spasm in the limb which thus passes through a "white" stage. This may rarely lead to some necrosis, a condition referred to as *phlegmatia cærulea dolens* Such

a limb requires rest and elevation while heparin or other anticoagulant therapy is immediately instituted If infection is present, antibiotics are given and as soon as possible the patient is encouraged to get out of bed and walk about. It is usual for the limb to swell with such exercise and the use of a well-fitted elastic stocking is useful. Such limbs very commonly undergo ulceration after the passage of some years.

Localized Venous Thrombosis

Certain veins or venous systems in the body are particularly liable to thrombosis. The ætiology of the clotting is often unknown, but the clinical



FIG. 37 18. COLLATERAL CIRCULATION IN INFERIOR VENA CAVA OBSTRUCTION.

pattern is frequently one which is easily recognized A number of the more important of these is listed below

Axillary Vein. Spontaneous thrombosis of the axillary vein has been described for a long time and is typically seen in an individual who is using the arm in an unaccustomed manner Pain is usually not marked although the limb may feel heavy and numb The skin often becomes cold and a little cyanosed and the peripheral veins are distended especially over the back of the hand A little œdema may arise. The main sign is a tender palpable solid cord in the axilla

Treatment is not necessary for this condition since it always resolves spontaneously However the tenderness and numbness may make it necessary for the patient to support the limb in a sling for a few days. Gentle exercises and massage may speed recovery

Pampiniform Plexus. Thrombosis of the plexus of veins surrounding the spermatic cord can give rise to a picture somewhat resembling epididymo-orchitis or torsion of the testis or its appendage. The palpation of tender thickened veins makes the correct diagnosis certain. The only treatment necessary is a suspensory bandage.

Leg Veins. Thrombosis of the deep veins of the calf and leg is particularly liable to occur in the mother after childbirth and results in the condition known as white leg. Its pathology, progress and treatment is described in the section devoted to phlebothrombosis.

Vena Cava. *Superior Vena Cava.* This may be thrombosed owing to external pressure usually by tumours of the bronchus, but occasionally by mediastinal growths or even a large retrosternal goitre. As a result, collateral veins are seen coursing over the upper chest and neck and the patient may have attacks of giddiness.

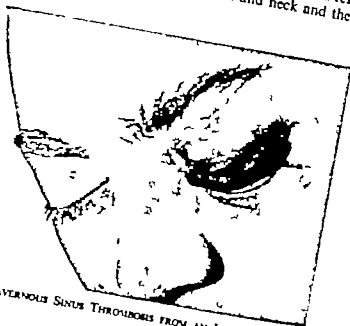


FIG. 37.19. CAVERNOUS SINUS THROMBOSIS FROM AN INFECTION ON THE FACE.

Inferior Vena Cava. This also may be thrombosed either as a result of external pressure or from an ascending thrombophlebitis from the leg veins. Eventually a collateral venous circulation develops over the lower abdomen and presents the picture seen in Fig. 37.18. There may also be swelling and œdema of the lower limbs which persists and requires treatment by firm bandaging or elastic stockings.

Anterior Pituitary Veins. In the post partum period there is a particular tendency to spontaneous thrombosis as typified by deep vein thrombosis in the lower limbs leading to a "white" leg. In addition to this there may be a spontaneous thrombosis of the veins draining the pituitary leading to ischæmic necrosis. This is probably due to the highly vascular state of the pituitary during pregnancy followed by a sudden drop in blood pressure which may accompany post partum hæmorrhage. Every degree of necrosis may occur from slight to complete. The resulting syndrome combines the features of hypothyroidism, hypogonadism and adrenocortical insufficiency. The appearance is often one of premature senility with fine, wrinkled yellowish skin, amenorrhœa or sterility, lack of body hair and great loss of

energy The condition is referred to as Simmonds's or Sheehan's disease and is treated by replacement therapy with cortisone and thyroid by mouth

Cavernous Sinus. Thrombosis of the cavernous sinus usually results from a pyogenic infection somewhere in the facial region which spreads back along venous radicals by direct extension The clinical picture which is seen in Fig. 37 19 is one of intense chemosis, proptosis and œdema associated with severe toxæmia and a high swinging temperature The treatment is the administration of antibiotics to which the organism is sensitive accompanied by the release of pus, if any is contained within the primary lesion. Anticoagulants such as heparin may be of value

Lateral Sinus and Jugular Vein. Thrombosis of the lateral sinus usually spreads from a middle ear infection and is a recognized complication of mastoiditis. The condition is discussed in Chapter 28

Chapter 38

THE HEART

Introduction

During the past few years a large number of patients with heart disease have been operated on successfully The greatest field for surgery has been in cases of mitral stenosis where splitting open the fused valve edges has allowed the return of a normal flow of blood from left atrium to ventricle. The other important field has been in congenital heart disease where certain stenoses and shunts have proved amenable to surgical treatment. In any prospective operation on the heart an accurate assessment of the hæmodynamic problem is necessary and though this may be achieved by ordinary clinical and radiological methods the use of cardiac catheterization and angiocardiography is often indicated Meticulous pre-operative preparation and treatment is required in any patient in whom there has been heart strain or failure, and a restricted fluid intake salt free diet and digitalis therapy result in clinical improvement and reduce the risks of surgery

Methods of Investigation. *Radiology* Radiological examination in any cardiac condition is concerned with the size and outline of the heart shadow and the extent of the pulsation of its margins Displacement of the oesophagus by the aorta or by the left atrium can be detected by a barium swallow The vascular pattern of the lung fields has to be observed and by determining the size and extent of the pulsation of the lung vessels, a great deal of information is gained about the pulmonary circulation.

Cardiac Catheterization. This consists in introducing a fine catheter into an antecubital fossa vein and passing it into the heart, where the position of its tip is observed by fluoroscopy Pressure recordings can be made during the passage of the catheter through the right atrium, ventricle, pulmonary artery and finally the small arteries proximal to the lung capillaries Specimens can be taken for measuring the oxygen content at various points An abnormal pressure gradient may indicate a narrowing or stenosis and changes in the oxygen saturation point to a fistula or shunt

Angiocardiography This is performed by the rapid injection of a radio-opaque solution into the circulation and taking skiagrams as the substance passes through the heart. If a series of two-plane radiographs can be simultaneously exposed within one half to two seconds of the injection the heart chambers will be clearly outlined and a number of defects and deformities can be visualized The technique and apparatus for this investigation is both complex and expensive.

Congenital Heart Disease

Patent Ductus Arteriosus. The ductus arteriosus is a fœtal channel which conducts blood from the pulmonary artery into the aorta. Normally as soon as the lungs expand at birth it is obliterated and persists only as a

fibrous cord the ligamentum arteriosum If it remains patent after birth the flow of blood goes from the zone of high pressure in the aorta through the ductus into the lower pressure of the pulmonary circulation Or to put it in another way as the resistance of the systemic circulation is much greater than that of the pulmonary lung fields the flow is from the left to the right side of the heart. As a result of the excess blood passed into the pulmonary circuit the pulmonary vessels become engorged with additional fully oxygenated blood There is thus no cyanosis The left heart undergoes some degree of hypertrophy to overcome the loss through the fistula with

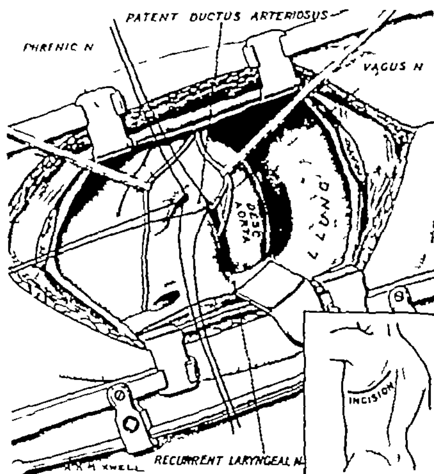


FIG 38 1 THE OPERATION FOR PATENT DUCTUS ARTERIOSUS.
The second rib has been resected and the mediastinal pleura opened.

each heartbeat. In the pulmonary circulation there is a marked increase in the flow and in a small proportion of patients a peripheral resistance develops in the pulmonary vascular bed, with the result that an obstruction is produced to the right heart output. In consequence the pressure in the right ventricle rises to overcome this and in the course of time the pressure in the right heart may approximate that in the left side and lead to a reversal of the shunt.

Symptoms Patients with persistent ductus arteriosus are often symptomless and indeed suffer little disability until they reach adult age. On the other hand, there are several risks that occur if the ductus is allowed to remain. These include infective endocarditis, hypertrophy of the left heart

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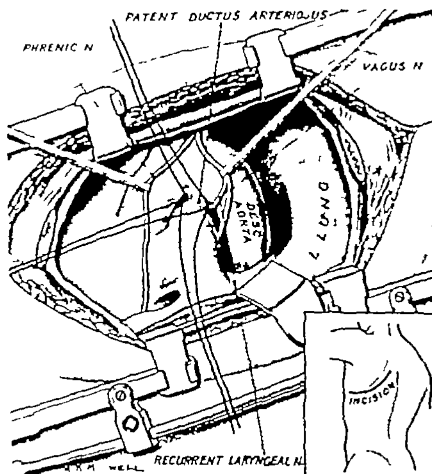


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Symptoms Patients with persistent ductus arteriosus are often symptomless and indeed suffer little disability until they reach adult age. On the other hand, there are several risks that occur if the ductus is allowed to remain. These include infective endocarditis, hypertrophy of the left heart

which may ultimately lead to failure, pulmonary hypertension with an additional strain on the right heart and finally cardiac invalidism which results from the repeated examination of these patients and from the knowledge both to the child and the parents that there is something wrong with the heart.

The patient is usually normal in build and appearance but with large shunts there may be stunting of growth The character of the pulse is collapsing, owing to the large pulse pressure produced by the low diastolic pressure caused by the leak from the aorta. Over the pulmonary area the loud continuous "machinery" murmur of the Gibson type is usually heard. Radiologically the heart beats vigorously and there is an enlarged pulmonary conus in the lung fields the pulmonary vessels will be seen to pulsate vigorously The policy adopted towards this condition is to close the ductus before school age if it is recognized early enough. This will avoid complications and once the ductus has been closed the heart and circulation are restored to normal The risks of the operation are small and not more than 1 or 2 per cent. mortality need be expected

Treatment A left thoracotomy is performed and the lung retracted so as to expose the mediastinal pleura This is incised leaving the arch and upper part of the descending aorta exposed but avoiding the vagus nerve with its recurrent laryngeal branch which passes round the lower aspect of the ductus The common pulmonary trunk is also identified and between the aorta and this trunk lies the ductus, usually a channel about 1 cm long and 1 cm wide Careful dissection isolates the ductus which is then either ligated firmly with stout ligatures or secured by clamps prior to division followed by suture of the cut ends. The policy of ligature is practicable in children but in adults where there is more likely to be atherosclerosis, ligation is not suitable and division should be performed The only real danger of the operation lies in the risk of tearing the ductus. Should this occur the surgeon must be prepared to control both the aorta and the pulmonary artery so that the hemorrhage can be arrested with a minimum of delay and the ductus divided and its cut ends securely sutured

Atrial Septal Defects. One of the most common congenital lesions in the heart is a communication between the atria This is consequent upon failure of the primary or secondary septum to close The *ostium primum* lies with its lower margin against the tricuspid and mitral valve rings and constitutes a difficult surgical problem. *Ostium secundum* which is the more common lesion is situated in the region of the fossa ovalis and consists of a large communication between the two atria In these cases there is a left to right shunt with a big flow through the communication. In consequence the right heart has to contain more blood than normal and as the shunt may be in the region of 5 10 or even 15 litres per minute the flow through the right heart is several times as great as through the left. The right heart becomes enlarged the pulmonary artery distended and the lung fields engorged As a result of the increased flow pulmonary resistance with subsequent hypertension may occur

The majority of these patients are symptomless and are recognized by the existence of an over active right heart of a systolic flow murmur over the pulmonary artery and of a split second sound Electrocardiographic changes also occur but diagnosis and an assessment of the severity of the condition can be made accurately only by cardiac catheterization. As a

result of the interpretation of catheter findings it will be found that the proportion of unsaturated blood in the great veins suddenly rises when the catheter tip reaches the right atrium and the oxygen content suddenly increases because of the flow from the left atrium into the right In adult life there is a considerable risk of right heart failure the heart being grossly enlarged with an enormous right atrium and ventricle

Treatment The remedy in these cases is to close the opening between the atria and a most satisfactory method of achieving this is to operate on the patient using *hypothermia* With the temperature reduced to 30 C

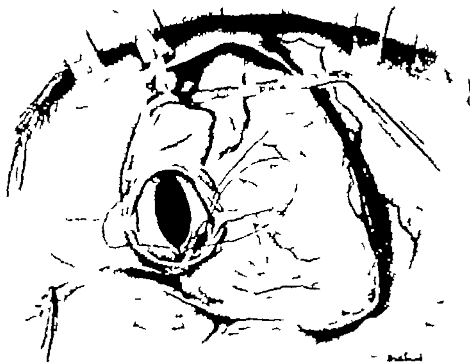


FIG 38 2. CLOSURE OF AN ATRIAL SEPTAL DEFECT UNDER HYPOTHERMIA.

An anterior bilateral thoracotomy has been used to expose the heart. Superior and inferior venæ cavæ have been surrounded by tourniquets which are occluded. The arterial outlet from the heart is closed by a clamp through the transverse sinus across the pulmonary artery and the aorta. The right atrium is opened and the defect in the region of the fossa ovalis is closed by direct suture.

(86° F) the circulation may be safely arrested for a period of seven *minutes* During this time the right atrium can be opened and the defect within the heart closed by simple suture under direct vision. The approach to the heart is through a transverse bilateral thoracotomy along the fourth inter costal spaces with division of the sternum On retraction of the divided chest wall the pericardium is fully exposed and then opened. The superior and inferior venæ cavæ are dissected and are encircled by tapes which can act as temporary tourniquets during the opening of the heart. A control clamp is placed with one blade through the transverse sinus of the heart so that the aorta and pulmonary artery can be shut off Occlusion of th

heart is effected by tightening the vena caval tourniquets, allowing the he to beat ten or twenty times and then applying the arterial clamp. The rig atrium is opened through a previously made incision and the defect visualize after blood has been sucked away. The opening is closed by simple sutur Air is expelled from the atria by the gush of blood that occurs as the vena caval tourniquets are released and the incision in the atrial wall is closed by a clamp. The arterial clamp is released at the same time and the circu-lation restored. When the heart is beating satisfactorily the wound is closed and the patient re-warmed. Results of the operation have proved good and it can be carried out with little risk and few complications.

An alternative method to hypothermia is the use of a "well" sutured to the atrial wall, a method introduced by Gross. After the well has been attached to the atrium the latter is opened and the septal defect palpated. The opening is then closed by direct suture or by applying a patch of poly vinyl sponge by mattress sutures, the whole being done blindly and by touc under the surface of the blood. The advantage is that there is no lim to the time allowed for the repair.

Ventricular Septal Defects. Small openings in the interventricular septum permit a large amount of blood to shunt from the left ventricle into the right ventricle, thus overloading the pulmonary circulation. Pulmonary hyper tension is common in cases of an isolated defect. In a number of instances, such as Fallot's tetralogy, the defect serves to take the load off the right ven-tricle when there is excessive hypertension as a result of severe pulmonary stenosis. The only effective way in which this type of defect can be closed is by open heart surgery using extracorporeal circulation.

Pulmonary Stenosis. Pulmonary stenosis consists of any form of obstruc tion to the outflow tract of the right ventricle. It may exist as an atresia of the pulmonary artery, stenosis of the pulmonary valve, or a narrowing of the infundibulum. If the stenosis is severe there must be some form of compensatory mechanism if the patient is to survive. This most commonly takes the form of a patent interventricular septum so that there is a bypass by which blood can flow from the right heart to the left. With obstructio to the right outflow the right ventricular pressure is high and in cases of Fallot's tetralogy, which is one of the most common forms of pulmonary stenosis, blood from the right heart enters the aorta with resultant central cyanosis. This form of cyanosis is characterized not only by blueness in the extremities but by clubbing of the fingers and toes. At the same time, inadequate circulation to the pulmonary vessels implies that there will be considerable shortness of breath on exertion. The characteristic features of Fallot's tetralogy are central cyanosis and shortness of breath on exertion which may be extreme. The disability is so marked that any form of relief is of the greatest service to them and their family. The condition is charac terized by a pulmonary stenotic murmur and, on radiology, by the absence of the pulmonary conus and no pulsation of the pulmonary vessels in the lung fields. There is also a considerable degree of right ventricular enlarge ment. Cardiac catheterization gives important information as to the position of the stenosis and the changes in the pressure gradient indicate whether the latter is valvular or infundibular.

Treatment. Two methods of treatment are used in pulmonary stenosis. One is to approach the stenosis directly and to excise it either through the ventricle or pulmonary artery, or open operation using hypothermia or

heart-lung machine. The alternative and original method of treatment for Fallot's tetralogy is the Blalock operation in which a systemic vessel is anastomosed to a pulmonary vessel so that the deflected blood flow from the systemic circulation enters the lungs and thus becomes fully oxygenated This shunt must be made of sufficient size to allow increased oxygenation but not so large as to throw too great a strain on the left heart as a result of the leak The Blalock type of operation consists in making an anastomosis between the right or left subclavian and the corresponding pulmonary arteries. This is carried out through a thoracotomy incision. The pulmonary artery is isolated and the subclavian artery dissected in the neck after

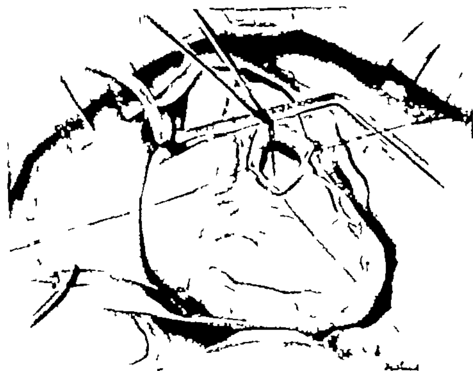


FIG. 38 3 OPEN DIVISION OF A STENOSED PULMONARY VALVE.
The heart has been occluded under hypothermia. Both venae cavae, the aorta and the pulmonary artery have been clamped The pulmonary artery is incised and the cone shaped valve divided in two places with scissors.

division of its branches between ligatures so that sufficient length is available to bring the cut end of the subclavian artery to the side of the pulmonary artery The vessels are controlled by clamps and an end-to-side anastomosis performed with a single layer of sutures. In Potts's operation a side-to-side anastomosis is carried out between the descending aorta and the left pulmonary artery The results of this operation have proved extremely satisfactory and though there is an appreciable mortality the benefits obtained are most gratifying, especially in the very young.

In the case of a " pure " pulmonary valve stenosis, a stenosis without an interventricular defect, the obstruction is treated more directly In Brock's

operation following thoracotomy an approach is made through the wall of the right ventricle using a knife-like valvotome and dilators. The stenosed valve or obstruction is divided, dilated or punched out to leave an adequate channel. The incision into the ventricle is controlled by pressure of the finger and finally closed by suture without much blood loss. The same type of procedure can be used through the left pulmonary artery passing the instruments in a retrograde manner to the obstruction. More recently an excision or division of the obstruction under direct vision making use of hypothermia has become increasingly popular. Under hypothermia, or with perfusion the upper part of the right ventricle or pulmonary artery can be incised, the stenosis visualized and divided or excised and the incision sutured before the heart is returned into circulation again.

Coarctation of the Aorta. Coarctation of the aorta consists of a stenosis or stricture of the aorta in the region of the ductus arteriosus. The stenosis may occur anywhere on the arch of the aorta but this is less common than the site mentioned. The result of this obstruction, which is congenital in origin, is to give rise to marked hypertension above the site of the obstruction and a considerable degree of hypotension below. The blood supply to the descending aorta is insured by a mass of enlarged collateral channels along the posterior scapular and internal mammary arteries, communicating with tortuous and dilated intercostals which enter the descending aorta and give sufficient flow to maintain the nutrition of the kidneys and other organs below the obstruction. The hypertension in the upper part of the body is of considerable danger to the patient. Not only does it produce symptoms in early adult life but about middle age it will almost certainly lead to some form of major cardiac or cerebral disaster. It is consequently imperative that the coarctation should be relieved at the earliest possible moment in the hope that the hypertension may resolve in part if not completely. As with so many congenital conditions the patients usually have few if any symptoms and indeed are remarkable for being extremely fine physical specimens. Marked pulsation is to be noted in the base of the neck and about early adult life headaches, giddiness and loss of vision may indicate that hypertension is becoming increasingly severe. The diagnosis is made by recognizing hypertension in a young patient and finding that the femoral pulses and the pulses in the legs are impalpable or have a very poor excursion and further that they are not synchronous with those in the arms. The heart is enlarged and may have an aortic stenotic or regurgitant murmur. Palpable arteries are felt in the posterior scapular region and along the course of the anterior perforating vessels of the internal mammary artery.

Radiologically there is evidence of an enlarged aorta, an enlarged subclavian artery and most important notching of the ribs produced by pressure ulceration of the tortuous, grossly enlarged and almost aneurysmal intercostal arteries.

Treatment. This consists in relieving the stenosis by excision and if possible end-to-end suture of the aorta as first practised by Crafoord. If as is common the stenosis is short it is possible to mobilize the aorta above and below the obstruction and after excision of the coarctation make an end-to-end junction between the divided ends of the aorta. The dissection is difficult owing to the delicacy of the vessels and the enlarged collateral channels but if carefully performed there is little danger in the operation. If the stenosis is of any length and more than one or two centimetres have

to be excised the gap may be bridged by turning down the left subclavian artery which is divided towards the apex of the chest and anastomosing it to the descending aorta Alternatively and this becomes necessary if any aneurysm has had to be resected an aortic or plastic graft is inserted

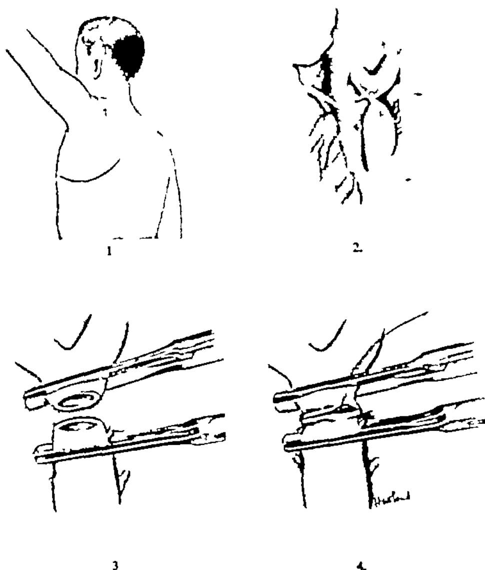


FIG. 38 4 COARCTATION OF THE AORTA.

1 The incision.
2 Showing the area of the coarctation after division of the mediastinal pleura. The ductus lies just above the coarctation. The large subclavian artery curves upwards from the arch of the aorta. Below the coarctation the descending aorta is large and has tortuous dilated intercostals entering into it.
3 Following dissection, clamps have been applied to the aorta and the coarctation resected.
4 Anastomosis almost completed. Everting arterial sutures are used.

Acquired Heart Disease

Mitral Stenosis. Stenosis of the mitral valve is one of the most common forms of heart disease. It is due to rheumatic endocarditis which, by forming vegetations, causes the valves to become adherent and so contracts the

of the heart is to take more than ten minutes extracorporeal circulation has to be used Perfusion of the body while the heart is being occluded is carried out by using a heart lung machine of which there are many varieties The principle underlying such apparatus is the removal of blood from the venae cavae by catheters and the transference of the blood to some form of oxygenator from which it is pumped into the arterial system via the subclavian or femoral artery The blood is prevented from clotting by the use of heparin which is neutralized at the end of the operation by protamine. Several pints of blood are required to prime the machine.

A number of different heart lung machines are in use and they mainly differ in the type of oxygenator used The Gibbon-Mayo apparatus uses vertical mesh screens across which the blood is filmed in an atmosphere of oxygen. Melrose and Aga oxygenators pick up the blood on discs which revolve A different principle is adopted in the Lillehei de Wall machine which bubbles oxygen through blood in a vertical column and then removes the bubbles from the oxygenated blood by passing it through a spiral of tubing. There are many complications which can be attributed to perfusion but successful operations have been achieved with a perfusion time of up to an hour

Using this method it is possible to open the right ventricle or atrium and to repair any internal defect. With operations on the right heart the use of *electire cardiac arrest* is valuable In this procedure potassium citrate is injected into the base of the aorta so that it reaches the coronary arteries and causes complete standstill of the heart. Flushing the solution out of the coronary system allows the heart beat to return

Ventricular septal defects, severe stenosis of the right outflow tract and common atrioventricular canals have been successfully operated on with this form of technique

Myocardial Ischæmia. Many methods, involving a diversity of operations have been suggested for the treatment of myocardial ischæmia or coronary artery disease to endeavour to form a new blood supply to the heart muscle Most attempts have aimed at inducing a new blood supply between the surface of the heart and some adjacent structure such as pectoral muscle the pericardium itself or omentum brought up through an opening in the diaphragm In spite of the good results claimed for these operation they have not been generally accepted as proving of any permanent value

Diseases of the Pericardium

The pericardium is a fibroserous sac which is capable of a certain amount of distension as a result of effusion The effect of any increase of pressure within the pericardium limits the diastolic relaxation of the heart and if this becomes extreme "tamponade" develops. Tamponade, or compression of the heart, depends for its severity on the rate of the process. Three forms of tamponade can be considered acute subacute and chronic.

Acute Tamponade A sudden accumulation of fluid if unrelieved, rapidly brings the heart to a standstill. This is most commonly seen in penetrating wounds of the heart which lead to loss of blood from the heart into the pericardium If there is an opening from the pericardium through which the blood can escape the danger of tamponade is avoided though the bleeding continues Blood that cannot escape compresses the heart and produces a severe fall in the blood pressure Acute tamponade requires

urgent relief if the patient is to survive If the condition is recognized an incision should be made over the lower costal cartilages to expose the pericardium The tense purple sac is incised and blood gushes out When the heartbeat has recovered the wound within the heart is identified and if possible closed by suture It is not often that patients can be treated sufficiently early but operation may well be life-saving.

Subacute Tamponade This form of compression of the heart results from the accumulation of an inflammatory effusion It may follow suppurative infection of the pericardium but is more often seen with a tuberculous effusion. This may become chronic, with thickening of the pericardial walls later these pericardial walls contract and become fibrotic leading to permanent constriction or compression of the heart a condition of *constrictive pericarditis* Subacute tamponade due to effusion requires aspiration of the pericardium Paracentesis can be performed anteriorly through an intercostal space but the risk of puncture of the internal mammary vessels and damage to the pleura makes it preferable to use an inferior approach. This should be carried out between the costal margin and the xiphisternum working upwards and extraperitoneally through the diaphragm into the inferior aspect of the pericardial sac, where the risk of injury to the heart and other structures is minimized

Constrictive Pericarditis (Chronic Tamponade) This condition is produced by extreme contraction of the pericardium around the heart It usually results from tuberculous pericarditis, occasionally from suppuration but it is never caused by rheumatic infection The pericardium which becomes thick, cicatrizes and contracts until what was originally a loose fibrous membrane develops into a dense cuirasse around the heart. This casing may become calcified and cold abscesses may be formed. The areas affected by the constriction are usually over the ventricles, particularly in the atrioventricular groove The result of this " corsetting " of the heart is to limit the diastolic relaxation It has been said that the condition is caused by constriction round the atria and great veins but in most cases the evidence to support this theory is not strong.

Failure of diastole results in the heart being unable to receive the whole of the venous return The blood becomes dammed back and in time produces a raised venous pressure which is responsible for the signs and symptoms of the disease It is convenient to divide the signs into those that are above the heart, those that are below and those connected with the heart itself The signs of raised venous pressure above the level of the heart consist of engorgement of the veins in the neck and arms. There may be a certain amount of chronic œdema round the lower jaw Below the heart the most striking features are enlargement of the liver and the ascites which may be considerable. Œdema of the legs is usually less marked than might be expected The heart itself may not show very much alteration in size but on fluoroscopy there is a definite limitation of its movement This limitation may not be severe but is certainly marked when compared with a normal individual. There may be little or no history of onset and the progress of the disease is slow often taking a period of years. On auscultation, the heart sounds are diminished but are not necessarily absent, as they would be in the case of a pericardial effusion Irregularities of rhythm are common.

Treatment This consists in excision of the pericardium from the surface

of the ventricles. The heart is exposed through an anterior or posterior left thoracotomy and after the lung has been retracted a whitish solid mass of thickened pericardium lying over the heart is observed. There is little or no pulsation in this. The thickened pericardium is incised until the brown-red myocardial fibres are recognized and by careful and slow dissection the pericardium is excised from as much of the ventricles as possible, taking care to avoid damage to the coronary arteries and the left phrenic nerve. The patient's general condition does not always permit a very wide excision of the pericardium but a limited operation may give considerable improvement. A more extensive approach is sometimes obtained by splitting t' sternum longitudinally or by using a transverse thoracotomy dividing th sternum horizontally

The results of pericardiectomy are satisfactory though the operation itsel is not without hazard When the heart has been freed from its rigid casing it relaxes and regains diastolic filling. The circulation improves as the venous pressure falls, with rapid recession of liver enlargement and the ascites Cardiac irregularities which were present before the operation usually persist

Cardiac Massage

Cardiac Arrest. As a result of experience with heart surgery a great deal of information has been gained about the value of cardiac massage in cases of cardiac arrest The condition nearly always arises as a result of coronary anoxia and is frequently seen in association with an obstructed airway The essential point is to recognize the condition early and to waste no time in treating it Standstill of the heart is recognized by failure of the pulses and absence of a palpable or audible heartbeat. The matter is urgent and there should be no question of losing several minutes in deciding whether or not the heart is beating or using stimulants or drugs in the hope that they will resolve the condition Various methods of approaching the heart for massage have been suggested but the only one that is really effective is a left transthoracic incision Once cardiac arrest exists the operation field will be bloodless A left submammary incision is made close to the sternum through the third or fourth intercostal space and the pericardium incised so that the hand can be passed into it and can then grasp the heart which is squeezed vigorously enough to empty it of blood

Cardiac massage consists in compressing the heart sufficiently firmly to make a carotid pulse palpable in the neck but not so firmly that the comparatively soft myocardium is contused The heart should be emptied about sixty times a minute and as long as a palpable pulse is felt in the carotid arteries there will be sufficient circulation for the needs of the brain. At the same time the coronary circulation will be re-established and the myocardium has a chance of recovery The importance of speed in re establishing some form of circulation cannot be stressed too greatly Three to four minutes of absent circulation in the brain may lead to permanent cerebral changes even though the heart beat is restored by massage. During the period of massage, intratracheal oxygen administration must be carried out, keeping the lungs fully inflated The one drug that has any effective action on the heart at this stage is adrenaline (epinephrine) and it should be injected into the left ventricle so that it reaches the coronary arteries as soon as possible

If cardiac arrest occurs during the course of an abdominal operation it may be possible to massage the heart from below the diaphragm. However incision of the diaphragm and squeezing the heart within the pericardium is much more efficient.

Ventricular Fibrillation. This differs fundamentally from cardiac standstill or arrest. It is a condition which cannot be cured solely by massage but may require a high frequency electric current to bring the fibrillating myocardial muscle fibres into standstill, after which restoration of normal rhythm may be obtained by prolonged cardiac massage

Chapter 39

PÆDIATRIC SURGERY

Introduction

There are a number of reasons why those conditions occurring in infan and childhood requiring surgical care are grouped together rather tha included in other sections of this text book. In the first place, infants an children do not represent smaller editions of their parents, indeed ther respond quite differently to those physiological and pathological changes which accompany disease. Second there are several congenital abnormalities which are not compatible with life unless they are treated surgically without delay. Third many deviations from the normal in development, such as cleft lip and palate require treatment at an early age if the child is to be given the chance of developing normally both physically and mentally. Finally there is a whole group of conditions, only seen in infants and children, which require the attention of the surgeon and thus a definite speciality has grown up in this field in recent years. For the most part these younger patients are treated in this country in general hospitals and therefore it is general surgeons who operate upon them. This is a satisfactory arrangement when the children can be gathered together in a separate part of the hospital for the specialized nursing and attention they require and it is an interesting observation that most of the advances in this particular branch of surgery have been made by general surgeons who take a special interest in children rather than in those who have specialized exclusively in this field.

Some of these conditions are described elsewhere. Cleft lip and cleft palate are dealt with in the chapter on Plastic Surgery (Chapter 52). Hydrocephalus and spina bifida are considered in the neurosurgical section (Chapters 23 and 25) and the deformities of childhood are described in the orthopædic section (Chapter 11). Congenital heart disease is considered in Chapter 38.

A considerable number of congenital diseases affect the alimentary and urogenital tracts and these will now be described.

The Œsophagus

Atresia of the Œsophagus. This condition is found when the œsophagus fails to develop normally, the upper end terminating in a blind sac and the distal part usually connecting with the trachea near its bifurcation. Hence the condition is also often referred to as *tracheo-œsophageal fistula*. There are many variants of this abnormality but none of them is as common as that already described. This congenital abnormality should always be suspected when a new born baby becomes cyanosed and regurgitates its feeds. The child is typically bubbly and blue and if not treated dies from pneumonia in a few days or weeks. Diagnosis is readily confirmed by passing a fine lubricated catheter through the nose when it will be arrested at about

12 cm The injection of 2 or 3 ml of opaque oil enables skiagrams to be taken in both lateral and antero-posterior views (Fig 39 1) The iodized oil should then be aspirated so that it will not be inhaled into the lungs Barium should on no account be used because of this risk and the particularly severe bronchopneumonia which it produces The baby should at the same time be carefully examined for other congenital defects such as an imperforate anus or lesions of the heart and great vessels.

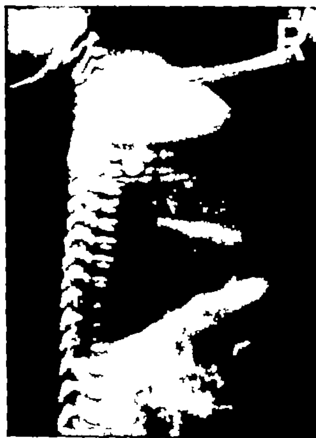


FIG. 39 1 ATRESIA OF THE ŒSOPHAGUS. LIPIODOL IS SEEN IN THE UPPER BLIND POUCH.

Treatment Once the diagnosis has been made the baby should be prepared for operation. If dehydration is present it is corrected by an intravenous infusion of half normal saline, but over hydration is a commoner fault than dehydration The baby is turned from side to side each half hour in order that the lungs will be well aerated and after the induction of anæsthesia and the insertion of an intratracheal tube, the right chest is opened through an intercostal incision in the third or fourth space The azygos vein is doubly ligated and divided and the distal part of the œsophagus detached from the trachea the opening in the latter being carefully closed. The blind sac of œsophagus above is then mobilized and anastomosed directly to the distal end over an indwelling catheter The chest is closed and an under water seal intercostal drain inserted Feeding by mouth with expressed breast milk is started within a few hours and it is rarely necessary to employ a gastrostomy Some surgeons prefer to use a fine polythene tube threaded

through the nose into the stomach in order that the feeding can be carried out without milk having to pass over the suture line

Hiatus Hernia. This condition is considered here since it primarily involves the œsophagus. Hiatus hernia is a condition in which the hiatus in the diaphragm through which the œsophagus passes is enlarged and the sphincter between œsophagus and cardiac end of the stomach is incompetent. As a result the baby regurgitates much of his feeds and constantly dribbles fluid and saliva from the mouth This regurgitation frequently leads to œsophagitis and there are recurring small hæmatemeses so that the baby becomes anæmic The condition is often mistaken for congenital hypertrophic pyloric stenosis The diagnosis, however can be confirmed by giving a small feed of thin barium to the baby and demonstrating the regurgitation on the fluorescent screen In addition to the failure to thrive and anæmia, the most serious complication is stricture of the lower end of the œsophagus, an example of which is shown in Fig 39 2.



Fig 39 — Stricture of the Œsophagus in an Infant

Treatment The treatment of hiatus hernia is unsatisfactory because it is still not clearly understood what is the exact abnormality which leads to the condition. In the milder degrees of this condition the baby is sat up in a well-padded box-like seat and in this position regurgitation is often greatly diminished If the baby starts to thrive it is frequently observed that the condition is self-limiting. If nursing the baby in the sitting position day and night for some months does not lead to general improvement, operation should be undertaken The chest is opened on the left side and the œsophagus carefully dissected from the hiatus to the level of the aortic arch. The stomach is then replaced in the abdomen and attached along its greater curvature to the undersurface of the diaphragm. The phrenico-

œsophageal ligaments are then used to anchor the œsophagus in its new position and finally the two portions of the right crus of the diaphragm which decussate to form the hiatus, are approximated by interrupted sutures either posterior or anterior to the œsophagus. This operation is successful in many babies and young children but it is not always so and may be followed by a relapse after a varying interval. Where stenosis of the œsophagus occurs it is necessary to dilate the œsophagus which should in the first instance, be done under general anæsthesia through an œsophagoscope. This allows the condition of the mucosa to be seen and the size to which bougies can safely be introduced. Subsequent bouginage can be carried out without anæsthesia so long as the gum elastic bougies are made more supple by placing them in warm water and lubricating them with a little glycerin. Finally if the stenosis of the œsophagus becomes so tight that the nutrition of the child is threatened excision of the stenosed area with anastomosis of stomach to œsophagus or in the most severe cases of jejunum to œsophagus by means of a Roux Y loop has to be adopted.

Intestinal Obstruction in the Newborn

Intestinal obstruction neonatorum can be due to a number of different lesions, but the presenting signs and symptoms are for the most part the same. Any new born baby whose abdomen becomes distended and who vomits bile-stained fluid has almost certainly an obstruction of the intestinal tract. Where the obstruction lies in the large bowel, vomiting may not arise for the first two or three days. On examining the abdomen the outline of the distended stomach or first part of duodenum may be seen through the abdominal wall when the obstruction is high, and visible peristalsis in the stomach resembles nothing so much as a golf ball being pushed slowly along just beneath the surface. Low obstruction may be revealed by a ladder pattern on the abdominal wall. Auscultation is occasionally helpful since increased peristalsis is readily heard above the obstructed area.

The most important single investigation and one which should never be omitted is a straight skiagram of the abdomen with the baby both recumbent and held upright. The radiological findings will be described in the various varieties of obstruction which are briefly outlined below.

Malrotation of the Mid-gut. In fœtal life, between the fifth and *tenth* weeks, most of the mid-gut passes out of the abdomen and into the umbilical cord. After this period it usually returns, in an anticlockwise direction, and eventually the mesentery of the small bowel becomes adherent to the posterior abdominal wall while the large bowel gains attachment in both the right and left lateral parts of the abdomen. If however the gut does not return according to this plan the whole of the middle portion may be rotated about its axis which thus imperils its blood supply and obstructs its lumen. The main obstruction usually consists of a band passing from the cæcum which lies in the upper left quadrant, to an area to the right of the duodenum and the hold-up is therefore in the second part of the duodenum. A skiagram of the abdomen thus shows a fairly typical gas bubble confined to the stomach and first part of the duodenum.

Treatment consists in aspirating the stomach contents through a fine nasal catheter and then under general anæsthesia, opening the abdomen through a long right paramedian incision. The mass of small bowel is

reduplication but this unfortunately cannot always be done In such circumstances it is justifiable to anastomose the duplicated loop to the normal bowel so that the contents are drained and it can no longer obstruct the lumen

Meconium Ileus. This remarkably interesting condition was first described over fifty years ago but only recently has been regularly recognized and rationally treated The primary lesion is usually fibrosis of the pancreas with absence of normal pancreatic secretion so that there is no trypsin in the bowel to liquefy its contents The contents of the bowel of the newborn are described as meconium and consist of a semi-fluid greenish-black homogeneous substance which is normally passed within the first thirty six or forty-eight hours of life In meconium ileus the absence of pancreatic



FIG. 39 3 MECONIUM ILEUS. NOTE STIPPLING OF BOWEL CONTENTS.

secretion prevents the normal liquefaction of the meconium which as a result is extremely viscid and obstructs the lower ileum where it can sometimes be palpated through a thin abdominal wall resembling a string of beads. A skiagram of the abdomen is diagnostic, for the meconium contains small flecks of air which appear as clear areas (Fig. 39 3) The condition is not confined solely to the pancreas for there is also lack of normal secretion from other epithelial surfaces especially the bronchi The condition has been called mucoviscidosis.

Treatment consists of relieving the obstruction, a difficult task Excision of the terminal ileum may remove a great deal of the extremely tenacious meconium and the rest may be expressed from the bowel an operation

Imperforate Anus

Imperforate anus is a term used to include those abnormalities where the rectum does not open normally to the surface. It is convenient to consider these conditions, from the point of view of treatment, in three degrees of severity. In the first there is merely a layer of skin covering the region where the anus should be; in the second a distance of not more than 2 cm. separates the blind end of rectum from the surface, while in the third degree there is a long blind segment between the patent bowel and the perineum.

First Degree. The baby is born without any opening to the anus and when crying, bulging is noticed in this area. If the skin is thin, the bluish meconium may be seen just beneath the surface. There may be a minute sinus visible a little anteriorly. Treatment consists of finding the small pit which is usually present and then enlarging it in the posterior direction with a pair of scissors. Some of the overlying skin may be excised and the edges united to the lining of the anal canal, after meconium has been mopped out. Whatever is done the final result should be indistinguishable from a normal anus. There may be a little tendency to narrowing which is readily corrected by digital dilatation by the mother during the first six months of life.

Anal stricture in the newborn may be considered a mild form of this condition.

Second Degree. The diagnosis of this condition from that where a long segment of rectum is atretic is made by radiography. In the normal baby air is swallowed immediately after birth and reaches the lower part of the



FIG. 39.4. IMPERFORATE ANUS.
THE BABY IS HELD UPSIDE DOWN.

alimentary tract in about eighteen hours. Therefore, if after eighteen hours the baby is held upside down and a skiagram of the rectal area taken in both antero-posterior and lateral views, a gas bubble will be seen and its distance

from the surface can be measured A small radio-opaque marker should be put on the skin at the site where the anus should be. It is rare to see an anal pit and usually there is a slight elevation in this area.

Where the gap between surface and blind rectum is not more than 2 cm. to 3 cm. it is possible to bring the rectum down by the perineal route. The baby is anæsthetized and put in the lithotomy position A fine catheter is introduced into the urethra. A vertical incision is made in the perineum at the site where the anus should be and carefully deepened to reveal the muscular fibres of the external sphincter These may be divided anteriorly and on gentle dissection the blind rectal stump is seen It is retracted by a number of small stay sutures introduced into its wall The anterior surface should be particularly well displayed since, in a little over three-quarters of these patients, a fistula will be found connecting the rectum and urethra or bladder neck. This connection must be divided before the bowel can be mobilized enough to bring it down to the surface The rectal stump is then opened meconium sucked out and the edges of the opening sutured directly to the skin The sphincter is united anteriorly and the skin closed The nursing of this type of patient is best carried out by supporting the legs on an overhead Balkan beam so that the buttocks are just clear of the cot A small electric lamp placed at the foot of the bed keeps the perineal area dry and as the motions are passed they fall clear of the suture lines on to a napkin placed conveniently below After-care consists of dilatation of the new anus digitally until normal function has been obtained

Third Degree. This category includes all those babies in whom a skiagram soon after birth reveals a long gap between the gas in the patent bowel and the surface. There are two methods of tackling this difficult surgical problem. In the first a transverse colostomy is made since this allows the bowel to work well and does not in any way interfere with that part of bowel which, at a later date will be required to construct a new rectum When the baby is a year old operation is performed with the legs supported in wide lithotomy and the body tipped into the Trendelenburg position. The distal sigmoid colon and if necessary the descending colon is widely mobilized and then brought down through an opening which is tunnelled in front of the hollow of the sacrum it is then brought out to the surface. The success of the operation depends on finding the external sphincter This may be done through a vertical incision or a horizontal one but it is essential to see the muscle fibres and to bring out the new rectum through this area The mucosa is sutured to the skin and it is very important that there should be no slack in the bowel for there is a great tendency to prolapse if this is allowed Subsequently the colostomy is closed and a long period of training confronts the mother since these children find it difficult to gain confidence Occasionally it is necessary to resort once more to a colostomy

The alternative method of treating these babies is to reconstruct the rectum soon after birth The baby is placed in the same position on the operating table and the bowel is mobilized from above and brought out through the perineum in the correct place It need not be sutured to the skin and if left to lie in its natural position can be trimmed off some days later

Rectovaginal Fistula. The rectum may open into the vagina at any level in its posterior wall but most commonly in the lower third Operation can be carried out at any age but is most conveniently left until after one

year of age because the size of the parts then makes the operation so much easier The baby is placed in the lithotomy position and the perineum explored through a transverse incision which permits adequate freeing of the lower part of the rectum and its detachment from the vagina. The lower end of the rectum is then brought out through the new opening the fibres of the external anal sphincter having first been carefully defined.

In some babies it is noticed that the vaginal and anal orifices are extremely close together the so-called "shotgun" perineum but no treatment is required for this. In others the anus may appear to be ectopic, having been displaced forwards, this is due to the fact that it is partly roofed over by perineal tissues. Slitting these in a posterior direction will reveal the proper site of the anus and will allow it to function normally

Conditions of the First Year of Life

Pyloric Stenosis. Congenital hypertrophic pyloric stenosis is a condition in which there is great hypertrophy of the muscle fibres making up the pyloric sphincter and also of those in the distal part of the stomach wall It occurs four times as commonly in male as female infants and may be inherited as a recessive characteristic. It has never been described as being present at birth and it is considered that the hypertrophy starts to develop only from that time reaching such a degree that symptoms usually begin to appear about the end of the second week of life. The pathology of the condition suggests that the abnormality is one of the myenteric plexus and that there is lack of proper maturation of the ganglion cells which resemble those seen during fœtal life. Such an explanation would account for the fact that the condition is a self-limiting one and no matter what the treatment, shows a tendency to correct itself during the first year of life.

Signs and Symptoms Typically a male infant, two weeks of age, starts to vomit his feeds and the vomiting becomes progressively more violent until it is described as projectile There is no bile in the vomit and on examining the baby he is seen to be dehydrated and there may be visible peristalsis. Waves of contraction resembling a golf ball, pass from left to right across the upper abdomen. Careful palpation of the abdomen to the outer side of the right rectus muscle, just below the costal margin, will reveal a small, hard oval tumour which, however does not appear to be present all the time.

Treatment This consists in the first instance of correcting dehydration which is usually effected by giving subcutaneous infusions of saline. The stomach is aspirated with a fine rubber catheter passed through the nose and this is also used to wash out the stomach, which often contains stale milk curds. When the baby is fit, usually after twenty four hours, operation is performed Local analgesia is to be preferred but a general anæsthetic may be given. If local analgesia is used not more than 5 ml of 1 per cent. procaine or lignocaine should be used, but this amount can be increased to 10 or 15 ml. of ½ per cent. solution. Larger quantities may have a toxic effect on the baby An incision is made either transversely in the upper right abdomen, obliquely beneath the rib margin on the right side, or vertically through the rectus muscle. The pylorus is gently delivered into the wound and a longitudinal incision made on its antero-superior aspect where there are no blood vessels. The gristly fibres are divided by blunt

dissection right down to the mucosa which will be seen bulging into the wound Should the mucosa be perforated, it is immediately sutured meticulously The pylorus is dropped back into the abdomen which is then routinely closed and the baby is started on small feeds by mouth after four hours and at the end of two days he should be back at regular four hourly



FIG 39 5 RAMSTEDT'S OPERATION FOR CONGENITAL PYLORIC STENOSIS.

feeds of breast milk This operation which was devised and first carried out by Ramstedt, is one which carries a very low mortality and is extremely successful. Most babies may return home about the fourth day and return to have the sutures removed from the skin the following week.

Intussusception. Intussusception in babies occurs usually in the terminal part of the ileum somewhere between the fourth and tenth month of life. The cause is not known but since the lymphoid patches in the terminal ileum are extremely hyperplastic at about the time of weaning, this has been suggested as a cause Rarely a polyp or a Meckel's diverticulum may be the start of an intussusception and this usually occurs in rather older children.

Signs and Symptoms It is usually a rather greedy and overweight male baby who is the subject of this disease. At about the time of weaning he suddenly screams, goes pale in the face and draws up his legs and is in obvious pain. A small amount of blood may be passed per rectum and since it is frequently admixed with mucus it has been described as resembling red-currant jelly Immediately after the attack the baby is relaxed and appears quite normal again only to have further similar attacks.

On examining the abdomen during one of these attacks, the muscles will be found to go intensely rigid. However after the attack it may be possible to palpate the intussusception as a sausage-shaped mass somewhere in the line of the colon. Rectal examination reveals no fæces but there may be a little blood on the finger

Treatment An intussusception demands urgent surgical reduction since the results depend on how quickly the intussusception is corrected Those coming to the surgeon during the first twenty four hours usually survive whereas after that time the results become progressively poorer In some clinics reduction is carried out by means of a barium enema, but a proportion of these fail and still require operation so that in many hospitals surgery is the standard form of treatment. A right paramedian incision is made, centred at the umbilicus, and fingers are inserted into the abdomen to locate the head of the intussusception which is then gently manipulated

back towards its origin Usually the last 2 or 3 inches are difficult to reduce and the bowel may have to be lifted out of the abdomen in order to achieve this. It is essential that the bowel should be most gently handled and



FIG. 39 6. INTUSSUSCEPTION VISUALIZED BY MEANS OF A BARIUM ENEMA.
The apex of the intussusception is seen as a convex impression in the opaque barium.

squeezed out no traction being put on the ingoing ileum On those rare occasions when it is impossible to reduce the bowel, resection must be resorted to with anastomosis of ileum to colon.

Megacolon. Megacolon falls usually into one of three categories (*a*) Hirschsprung's disease (*b*) functional megacolon and (*c*) those due to anal stricture. The diagnosis of the three can on occasion be difficult, but the typical features are as follows Hirschsprung's disease tends to occur in boys more commonly than girls and is frequently seen in brothers. It causes symptoms, either from birth or soon thereafter of increasing constipation accompanied by distension of the abdomen and failure to thrive. Examination of the rectum reveals that it is often narrow and contains little faecal matter or at most, a few pellets. Inserting a finger however often allows the release of gas and occasionally fæces. Functional megacolon results from a variety of causes but it is usual to find an enormous loaded rectum which requires emptying either by enemas or manual dis impaction Anal stricture is diagnosed at once by the difficulty encountered in carrying out a rectal examination the rectum is again very large and usually packed with fæces.

Hirschsprung's Disease This condition is due to the ganglion cells of the myenteric plexus being absent or grossly abnormal. The segment of bowel affected may be short extending only a little way into the sigmoid colon or long, affecting the greater part of the large bowel or even extending into the small gut Treatment, which was introduced by Swenson, is

excision of the affected length of bowel. In those patients with a short aganglionic segment, this consists of a rectosigmoidectomy. The rectum and sigmoid colon are carefully freed by the abdominal route and then the bowel is telescoped so that the dissected rectum and sigmoid are prolapsed through the anus. The bowel is then cut off and the colon united to the stump of anal canal just outside the anus and the suture line then allowed to slip back inside. In this manner the whole of the aganglionic bowel is excised while the normal sphincters are retained. The operation is attended by excellent results.

The long segment variety is more difficult to treat since a total colectomy may have to be performed and the ileum anastomosed to the stump of the rectum. It is remarkable that these patients often have only three or four motions in the twenty-four hours.



Fig. 39 7 Distended Abdomen in a Case of Hirschsprung's Disease

Functional Megacolon. This condition arises from a variety of causes. Usually the child has an anal fissure which makes defæcation very painful or he develops bad habits because of unwise parental supervision. As a result of this there is an increasing disinclination to have the bowels open and purges fail to alleviate the condition. Eventually the child has a distended abdomen, fæcal impaction and a rectum so loaded that it can only be emptied by manual methods. There is often a spurious diarrhœa due to decomposition, so that it appears that the child is having a bowel action daily. Treatment consists of repeated enemas and the institution of a proper daily régime of having the bowels opened. Often the diet needs supervising and the regular giving of a small daily purgative such as senna or a mixture of liquid paraffin and milk of magnesia, is necessary.

Anal Stricture. It is surprising how often this may lead to an otherwise unexplained megacolon. The stenosis may be due to an inadequate opera

tion for imperforate anus or it may be a true narrowing of the lower part of the rectum and anal canal which is occasionally seen as a congenital abnormality The child has obstinate constipation and eventually the bowel becomes so distended with fæces as to lack the power of emptying itself Treatment consists of adequate dilatation of the anus which usually has to be continued for up to a year and at the same time regulation of bowel habit

Abnormalities of the Urogenital Tract

A great many congenital abnormalities occur in the urogenital tract and these include an absent kidney or fused kidneys, double ureter and congenital hydronephrosis. Some of these conditions are referred to in the urogenital section, but below are described certain important lesions which require treatment in childhood.

Hypospadias. This is a condition in which there is maldevelopment of the ventral surface of the penis. As a result there is usually bowing of the organ and the urethral meatus is seen to lie somewhere along the under surface on the glans (glandular) on the shaft (penile) or in the scrotum (bifid scrotum) There is invariably a hooded prepuce and if the dorsal surface of this is carefully looked at, two " eyes will be seen."

Treatment The treatment of hypospadias should not be undertaken before the age of four years as the tissues are not really suitable before then and a small amount of co-operation on the part of the patient is very helpful The first stage in treatment is to correct the downward curvature which is carried out by *dividing the tissues transversely anterior to the urethral* opening, and then suturing them longitudinally The correction of the urethral opening may be carried out in one or two ways according to the severity of the condition. For the lesser degrees of hypospadias the operation devised by Ombrédanne is suitable and consists of bringing forward a purse of skin with the meatus at its lower point and at a second operation the opening on the glans is narrowed For the more severe degrees of hypospadias the operation introduced by Denis Browne is ideally suited In this operation a thin strip of skin is left along the ventral surface and this forms the basis for the new urethral tube The latter is constructed by mobilizing the skin widely on each side and bringing together the two edges using special sutures with glass beads and metal washers in order that the pressure from the stitches shall be evenly distributed over the skin edges Enough skin is obtained by a long dorsal slit or relieving incision on the upper surface of the penis and the urinary stream is temporarily diverted by a posterior urethrostomy the catheter being left in place for eight to fourteen days.

Epispadias. This condition is excessively rare and consists of maldevelopment of the superior aspect of the penis the urethral opening being near its root or on the anterior abdominal wall. Great difficulty is experienced in reconstructing a normal penis and there is usually absence of parts of the spongy tissue skin has to be brought down from the abdominal wall to be used for cover

Ectopia Vesicæ. This condition is also known as extroversion of the bladder The bladder mucosa opens on the anterior abdominal wall so that urine continuously dribbles away It is associated in the male with epispadias and there is always lack of development of the pubic rami so

that there is no pubic symphysis The disability is a terrible one since the individual is always wet. The accompanying smell is unpleasant and if the condition is left untreated it is usual, after the passage of many years, for the exposed bladder mucosa to develop malignant changes.

Treatment Treatment of ectopia vesicæ has followed two different courses. Early attempts consisted of trying to close the bladder using flaps from the abdominal wall This is still attempted by some workers and there has been a recent revival in its use. For the most part, however it leads to incontinence and therefore although the bladder and mucosa is closed in the patient is not greatly improved. A more satisfactory form of treatment follows the transplantation of the ureters into the colon so that the urine is diverted to the rectum and most children manage in quite a short while to develop the capacity of only having to empty the rectum three or four times by day and not having to get up at night With adequate methods of anastomosis there is little back pressure on the kidneys and it is unusual to get ascending infection of the urinary tract in childhood, although a similar operation carried out in an adult is not so likely to succeed. After transplantation of the ureters the bladder mucosa is excised and the abdominal wall repaired.

Meckel s Diverticulum

In about 2 per cent. of people a lateral outgrowth of the ileum may be found within 3 feet of the ileocæcal valve This pouch is due to persistence of the intestinal end of the vitelline or omphalomesenteric duct. The diverticulum may extend to the umbilicus in the form of a hollow tube lined by *mucous membrane, forming a congenital fistula It is more often patent* only for an inch or two and may end in a fibrous cord attached to the umbilicus or mesentery Usually it lies free in the peritoneal cavity

Complications. Though a Meckel s diverticulum is sometimes found at laparotomy it frequently gives rise to complications causing an acute surgical emergency

Inflammation. The symptoms and signs are so like those of appendicitis that distinction is usually impossible before operation The treatment is on similar lines.

Intestinal Obstruction Strangulation of a loop of intestine by the fibrous cord and volvulus of the portion of ileum containing the diverticulum are not uncommon

Intussusception This is of the enteric type, the diverticulum being the apex of the invagination

Torsion This is followed by gangrene perforation or peritonitis.

Peptic Ulcer The diverticulum may contain ectopic gastric mucosa and it is then subject to the complications of ulceration namely perforation or hæmorrhage. Occasionally pancreatic tissue may occur

Intraperitoneal Cysts. These may occur in the course of the vitelline duct They are lined by intestinal mucosa and their origin is indicated by fixation to either the ileum, umbilicus or both by a strand of fibrous tissue

Chapter 40

PLASTIC SURGERY

Principles and Technique

Almost a century and a half ago the term Plastic Surgery was first commonly employed to describe procedures designed to alter or to restore form Since then there has been a steady development of the techniques of tissue repair tissue replacement and tissue transference which has almost kept pace with the growing frequency of the ever more extensive injuries inflicted by expanding industrialization, by increasing transport speeds, and by wars. A large part of this development of plastic surgery has been made possible by progress in anæsthesia, by increasing knowledge of methods of resuscitation and perhaps to a lesser extent, by the introduction of antibiotics.

These skills are applied to the repair of lesions of the skin and subcutaneous tissue, whether these are the results of accident, disease or surgery as well as to the restoration of form and function in structure distorted by congenital or developmental abnormality or by trauma

Every patient presents an individual problem which can seldom be solved by a standardized procedure There are therefore but few "operations" which can be described. The basic procedures will therefore be indicated together with a few more specific instances of their application.

The principles are those common to all surgery and are based on the histology of normal reparative processes. Surface wounds are always prone to *infection* which is obviated by careful handling and meticulous accuracy of repair All undamaged vascular tissues possess the capacity of resistance to minor bacterial contamination, so that the likelihood of infection in any wound can be minimized by (*a*) Avoidance of trauma in handling (*b*) Accurate hæmostasis, and (*c*) Careful suture.

Instruments All instruments are light and non-toothed and fine hooks are used in preference to forceps in handling both skin and subcutaneous tissue

Suture and Ligature Material Fine silk fulfils most criteria as a skin suture as it is non-irritant, inelastic and easily knotted. Fine stainless steel wire may on occasion be useful, especially for subcuticular sutures. Hæmostasis is often carried out by "twisting off" small vessels, but care must be taken to clamp only the vessels and not to include surrounding subcutaneous fat When a ligature is needed very fine catgut is suitable

Technique of Wound Suture. There are four cardinal principles affecting technique.

(1) *Débridement* This can readily be overdone It should be used only when the wound edges are bruised and ragged. It is very seldom necessary in the face.

(2) *Hæmostasis* is of the first importance in all plastic operations.

(3) *Apposition of subcutaneous tissues* to eliminate all dead space.

(4) *Skin closure without tension throughout the full vertical extent of* dermis and epidermis. The sutures are inserted not more than ⅛ inch from the skin margin and to ensure perfect apposition through the full vertical extent of the wound they include a greater bite of deep tissue than of skin. They are normally removed in three to five days. Subcuticular stitches are useful when removal may be difficult (*e g* in an eyelid) when ordinary sutures are likely to leave a mark (*e g* in the skin of forehead or nose), or when they must be left *in situ* for longer than five days (*e g* beneath plaster). A subcuticular stitch cannot normally be taken out in less than five to seven days and it will always be easier to remove if it is brought out through the skin every 1–1½ inches (2 5–3 5 cm.).

It is usually desirable to reinforce the suture line with elastoplast after removal of sutures and to maintain this for about one week.

Hypertrophic Scars Any scar subject to tension or to movement will *become hypertrophic in response to the trauma inflicted upon it.* An incision which crosses an area such as the antecubital fossa in its long axis should therefore be avoided as should the suture of a wound in such a way as to produce tension. Incisions should as far as is possible follow Langer's lines and thus tend to be parallel to or in the normal creases of the skin and not at an angle to them. In some parts of the body and in particular over the deltoid or the sternum scar reaction is likely to be excessive whatever the direction of the wound and there appears to be no method whereby this can be avoided.

In spite of every precaution some scars will become red and raised and will occupy a greater area than did the original lesion. These are sometimes described as keloid and are due to an excessive vascular response to the dermal injury probably secondary to an undue sensitivity on the part of the patient to his own keratin or to foreign bodies. They tend to occur most frequently in patients with a fine skin well endowed with lanugo hair or in those with many sebaceous glands and they are most commonly seen in young people.

The scar reaches its most highly coloured and most prominent phase within the first two months. In this stage it is often intensely irritable. The colour gradually subsides and the scar becomes flat, white and papyraceous—the whole process taking from six months to many years to reach completion. Superficial X ray therapy is often a help in hastening the phases of resolution but it is valuable only if applied in the early stages.

Free Grafts

Only a small proportion of the problems of repair can be solved by using the simple techniques described above. The lesion more often presents the problem of restoration of tissue which has been lost so that not infrequently the importation of new tissue from elsewhere on the body is an essential. This can be done by two main methods which depend on the characteristics of the tissue required. Some tissues will withstand the temporary complete loss of blood supply caused by severance from the body and transference to the recipient area and such tissue is therefore capable of being treated as a *free graft*. A new blood supply must, however be established very quickly in order to ensure the survival of most of the individual cells in the graft.

For this reason free transplants are usually very thin and they are always implanted on to a vascular bed

Skin bone, tendon nerve, fascia, cartilage and cornea (and to a lesser extent) fat are all capable of being treated as free grafts For permanent survival in their new site it now seems certain that these tissues must be autogenous, *i e* derived from the patient himself Temporary survival of some tissues derived from another person (homogenous) or from another species (heterogenous) can be obtained and may be of considerable value.

For example homogenous skin and bone may be kept for some weeks in a "bank" at temperatures just above freezing, without losing its viability The former may be used to resurface an extensively burned patient and will persist for from ten to fifteen days. Even this time, however may mean the difference between life and death.

Bone may be used to fill massive defects such as may be encountered in some forms of spinal fusion but these transplants are merely bridges across which the patient s own bone can spread

Cartilage and cornea are substances which do not appear to need a direct blood supply and are therefore treated at least for a time as implants even when they are heterogenous.

There is much evidence to suggest that cartilage, either homogenous or heterogenous, survives unchanged only for a time and is finally replaced by fibrous tissue. This process may take years to be completed.

Corneal grafts remain satisfactory transplants only if they remain avascular If vascularization occurs the graft becomes opaque and is replaced by fibrous tissue.

For permanent survival therefore it seems that at the moment a tissue transplant must be autogenous.

Skin Grafts

All types of skin graft must be implanted on a vascular bed and should be maintained in close contact by sufficient pressure to ensure that serum or blood does not accumulate to prevent the ingress of small blood vessels. They will not survive on exposed bone, tendon or joint capsule.

Two main types are employed split skin grafts sometimes referred to as Thiersch grafts, and whole thickness grafts or Wolfe grafts.

Split Skin Grafts

Indications. (*a*) The immediate repair of any raw surface which is vascular *e g* an area exposed by accidental avulsion or an area such as a breast in which after the requisite surgical excision, insufficient local skin remains and (*b*) the resurfacing of skin losses due to burns or infection.

The donor area is usually the inner or the outer aspect of the thigh or the inner side of the arm. If the inner aspect of the thigh is to be employed, the knee is flexed and the hip slightly abducted and externally rotated Support beneath the thigh by an assistant s hands helps to provide a plane surface. If the outer aspect is used, the knee is flexed and the hip flexed and adducted to provide a tense flat surface on the postero-lateral aspect of the upper two-thirds of the thigh. Special methods of cutting may enable other areas to be used.

Methods of Cutting the Graft. *Free Hand* A Blair knife, a light long straight-bladed knife and a straight-edge of wood or metal is necessary

The edge of the board and the under surface of the knife are lightly coated with petroleum jelly The board is pressed on to the skin immediately in front of the cutting edge of the knife and the graft cut by an easy sawing movement.

By Dermatome One such instrument consists of a half cylinder to which the knife is attached. The clearance between the drum and the knife can be adjusted The drum and the skin are coated with rubber cement and when this is "tacky" the drum is pressed into place and the skin divided by a to and fro movement of the blade. Another recently introduced dermatome has an oscillating blade driven by an electric or pneumatic motor No cement is needed with this machine. Either instrument allows skin to be cut from areas from which a graft cannot readily be cut free hand (*e g* the abdominal wall), and it also provides a graft of even thickness.

However the graft be cut the donor area is firmly dressed with tulle gras (a fine meshed net impregnated with petroleum jelly) and left undisturbed for ten to twelve days, by which time healing should be complete. The graft itself is usually spread raw surface uppermost on a layer of tulle gras to provide easy handling, as if it is not so treated it tends to curl.

Fixation of the Graft. The graft on its tulle gras backing is placed raw surface downwards on the recipient area—overlapping the normal skin at the margins. Sutures are inserted at regular intervals round the margins, their ends being left long. A pad of moist cotton wool is built up evenly over the area of the defect so that it projects well above the surrounding surface. Over this are placed several layers of gauze. The long ends of the sutures are then tied over the whole mass to fix it into place and pressure is finally applied by elastoplast, or a crepe bandage. The amount of pressure on the graft should theoretically be equal to that in the capillaries from which the graft will ultimately derive its blood supply *i.e* about 30 mm. Hg. Such accuracy is seldom achieved but grafts are more likely to be lost through insufficient rather than excessive pressure. Care must always be taken to ensure that, in the process of applying bandage pressure to a graft, over enthusiasm does not produce a tourniquet effect on the distal part of the limb.

Pressure should be maintained for from two to seven days. The latter is the usual time in the treatment of surgical wounds which are sterile, while the former is about the earliest time in which a graft can become reasonably adherent and may sometimes be employed when an infected surface is being grafted. The reason for early removal lies in the fact that if say 80 per cent. of a graft has "taken" satisfactorily the accumulation of pus from the remaining infected surface may result in autolysis of some of the already satisfactory graft If the initial pressure is removed very early it is desirable to reapply firm dressings from day to day for about a week

Subsequent Treatment. When, at the first dressing, epithelialization is found to be complete, the marginal overlap of the graft is trimmed away and a light protective dressing applied for a few days.

Between the seventh and twentieth days the surface epithelium is usually desquamated and the surface tends to become very dry Daily massage with lanolin is helpful. When the graft is below the knee there is a tendency for vascular stasis and some œdema to occur in the bed on which the graft is lying and grafts in such an area should always be kept under constant very firm bandage pressure until they become completely stable. This may not be until the end of the third month.

When complete epithelialization has not been achieved at the first dressing, granulations between adjacent areas of graft are trimmed down and daily pressure dressings applied Any necessary regrafting can be carried out as soon as the granulations are clean and dry

Advantages (*a*) This is a simple surgical procedure which immediately closes a defect in the skin providing protection against infection and dysfunction. (*b*) Only the surface layers of the skin are transplanted and regeneration occurs from the remaining dermis so that the donor area heals readily and can be re-used within two to four weeks. (*c*) The chances of successful take are very high even in the *presence of some infection*

Disadvantages (*a*) The colour tends to be white or brown and the texture is not that of completely normal skin (*b*) Split skin grafts tend to shrink and this is specially noted on flexor surfaces.

Modifications of the Technique. *In Areas where much Exudate is Present* The graft after backing with tulle gras, is cut into squares about the size of a postage stamp. These are applied to the recipient area with their margins not more than ½ inch apart and pressure is applied in the usual fashion. The placing of the grafts in this manner allows any exudate to escape, without the risk that large areas of the graft will be floated away from the recipient bed.

Cavity Grafting Skin may be used to replace losses of mucous membrane in the reconstruction of such structures as the eye socket, the buccal sulcus, the nasal cavity the urethra or the vagina Such grafts are cut as thinly as possible to avoid the inclusion of hair follicles or sweat glands and for this reason are frequently taken from the arm. They are applied on a mould of dental impression compound which in turn is usually fixed by an appliance. Constant pressure is maintained for from three to six months to avoid contracture.

Whole Thickness Grafts

In contradistinction to the split grafts these include all layers of the skin and dermis but they may not include any subcutaneous fat.

Indications. Whole thickness grafts are indicated when their colour and texture is an advantage, as in facial repair or when their elasticity and freedom from contracture will preserve function as in reconstruction of the volar surfaces of the hand.

Technique. These grafts are cut from the donor area by dissection with an ordinary scalpel. They are shaped accurately to fit the defect for which they are intended. They do not require backing on tulle gras but they must be meticulously sutured into their new position The type of pressure described above is applied and maintained for seven to ten days.

The donor site is often chosen because of similarity in colour and texture between the skin in that area and in the position for which it is required The graft includes all elements of the skin so that healing of the donor site can occur only by ingrowth of epithelium from its margins. If the defect is small it is therefore closed by suture. If it be too large for its edges to be brought together it should be epithelialized by the application of a split skin graft.

Subsequent Treatment. All sutures are removed at the time of the first dressing. Any minute unhealed areas are dried with spirit and kept dry

Desquamation of the superficial layers is often seen and this process can be hastened by gentle daily massage with lanolin.

Advantages (a) There is very little tendency to contracture. (b) The colour and texture of the graft remains normal and is that of the area from which the graft has been taken. Care in choice of the donor site is indicated.

Disadvantages (a) The technique requires meticulous accuracy and is very time consuming. The success of the graft depends on its perfection. (b) These grafts will not succeed in the presence of infection. (c) The area from which the graft is taken presents a secondary defect requiring closure.

Bone Grafts

In plastic surgery bone for reconstructive purposes is most frequently derived from the ilium and less often from the rib The latter may be used for digital reconstruction and the former for the restoration of continuity in the bones of the face and for replacing lost contour

The crest of the ilium is exposed by dissection and the requisite amount of cancellous bone is removed. When restoring contour or providing continuity in say the mandible, the graft is cut into chips which are laid into the defect. Alternative methods of fixation between the fractured bone ends are necessary as the grafts provide no initial stability

A vascular bed for these implants is an essential. Fusion between the chips progresses very rapidly and splints can usually be discarded at the end of the fifth week. When splints have been unnecessary all external pressure dressings can be removed in one week.

Other Grafts

Fascia Grafts. Fascia is employed to replace some tendons, to reconstruct joint capsules or ligaments and to provide support to the face in some cases of facial paralysis

The fascia is most often derived from the fascia lata of the thigh. It can be removed by open dissection or by the closed method with a fascial stripper The defect in the covering of the vastus lateralis does not normally need to be repaired. The fascia is divided into strips of the requisite width and inserted under conditions of meticulous sterility The tissue retains its characteristic appearance and histology after insertion.

Tendon Grafts. Tendon is used for the replacement of severed tendons in the hand The usual donor is the palmaris longus or the plantaris. If neither of these is available the long extensor tendon to the second or third toe can be utilized without causing dysfunction.

Nerve Grafts. Nerve grafts are employed to bridge traumatic defects. The lateral cutaneous nerve of the thigh is often used and enough sections of this nerve should be employed to provide a bridge of a bulk equal to that of the nerve which is to be repaired Accuracy of apposition and freedom from tension are essential.

Fat Grafts. Fat is sometimes used to replace lost subcutaneous tissue. It is not usually very satisfactory as a graft as it tends to be absorbed and in part replaced by fibrous tissue On the rare occasions when it is indicated it is derived from the subumbilical area. It is best removed with a thin layer of deep fascia and it should be handled as little as possible to avoid damage to the fat cells.

Cartilage Grafts. Cartilage is used for the restoration of contour as in

the nose for support as in the reconstructed ear or eyelid and occasionally for the restoration of the joint surface in a digit. Sources of supply within the patient are the ear or the costal cartilages and such cartilage may also be transplanted from one patient to another Preserved ox cartilage is also available Absolute asepsis is essential as infection will be followed by extrusion Autogenous implants persist but those from other sources may disappear by aseptic absorption.

Cornea Grafts. Cornea is used for replacement of the damaged cornea when the remainder of the globe and its contents are normal Cadaveric cornea may be refrigerated and stored until required There is a tendency for some of these grafts to become vascularized and opaque whilst others retain their clarity

Skin Flaps

It is obvious that the scope of repair provided by applying the grafting techniques described above is very limited. It is often necessary to transplant areas of skin and its attached subcutaneous tissues to replace or restore damaged structures. This cannot be done by any process of free grafting. The tissue must be kept alive during all stages of its transference to its new site by retaining or creating an adequate blood supply for the purpose At the same time some diminution of the normal supply is almost inevitable and there will be a resultant decrease in the resistance of the tissue to the ingress of infection. Obviously such infection will most easily find an entry into tissues not protected by their normal skin cover It is therefore desirable that at the conclusion of each operative stage in the tissue transference there should be no raw surfaces, and no break in the epithelial cover which protects the underlying tissues from bacterial invasion.

Local Flaps

Transposed Flaps. These are used when it is desirable to transpose the defect to a new site in which it can be made good either by suture or free grafting. For example, an injury which exposes tendon or joint capsule cannot be repaired by free grafting because the lack of blood supply in the area is such that the skin graft could not survive. If the exposure can be covered by transposing a flap of skin and subcutaneous tissue from the neighbouring area this flap will survive by virtue of its own blood supply and the defect in the area from which it has been taken can be so arranged that it exposes a vascular area which will then support a free graft (Fig. 40 1)

Z plasty This is a particular and very useful form of flap which is applicable to tension lines. It transposes skin from each side of the tension line without creating a secondary defect (Fig. 40 2).

Rotation Flaps. These represent another modification which is available. The secondary defect is rendered capable of closure by the design employed They are best used as large rather than small flaps and are particularly applicable to the closure of triangular defects (Fig. 40 3).

Flaps from a Distance

These are employed when as is often the case, insufficient material is available in the immediate neighbourhood The commonest donor sites are the chest or the abdominal wall and sometimes the limbs.

Direct Flaps. These can be used when the donor and recipient areas can

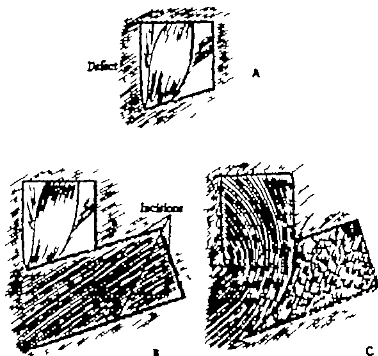


FIG 40 1 THE TRANSPOSED FLAP METHOD

Diagram A represents the exposure of an avascular surface which would not support a free skin graft.
At B and C the flap is raised and transposed to cover the defect, creating a secondary one which can be grafted.

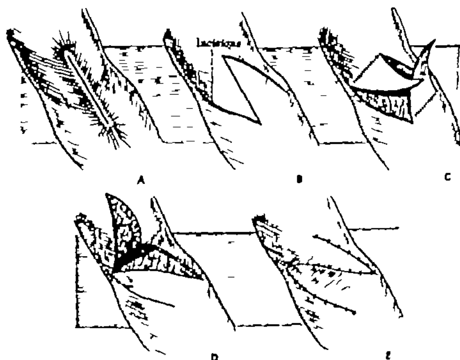


FIG. 40 2. Z PLASTY

Showing the necessary incisions and undermining prior to transposing the flaps to release the tension existing along the scar line.

be maintained in approximation without undue difficulty *e g* the arm can be *resurfaced from the abdomen, or the front of one leg can acquire a new skin* cover from the back of the opposite calf The flap should be so designed that the length of the base by which it remains attached to the donor area is greater than its other measurement. It is raised on three sides remaining attached by its fourth. The raw surface it leaves is covered by a split skin graft It should lie easily in its new position without strain or angulation. After two to three weeks it will have acquired sufficient blood supply from its new site to allow division of its base

When the donor and recipient areas cannot be brought into apposition such a flap can still be used if an intermediate vehicle be provided to ensure a blood supply during the transference, *e g* it may be decided to use abdominal skin to restore the skin of half the face. The requisite flap is planned on the abdominal wall and part of it is attached to the arm as described above In ten to fourteen days the remainder of the flap on the abdomen is undermined to cut off most of its original blood supply and make it more dependent on the vascular input it now derives from the arm. This process is known as a " delay " About ten days later the flap can be carried on the arm to be inset into the cheek Three weeks later the flap has acquired an adequate blood supply from the face and the attachment to the arm can be released

Such a procedure is possible only when the various stages can be so arranged that there is no exposed raw surface upon the completion of each phase An exposure of subcutaneous tissue will be followed by infection and fibrosis or possible loss In order to eliminate this risk completely the requisite piece of tissue is commonly converted into a tubed pedicle.

Tubed Pedicle. The requisite area of skin is outlined on the abdominal or chest wall. Incisions are made, preferably down to the deep fascia on the two longer parallel sides of the area The intervening bridge of tissue is dissected up to form a strap still attached at both ends. The edges of the strap are sutured together so that a skin-covered tube is created which contains the subcutaneous tissue in its interior The rectangular donor area is closed sometimes by approximation sutures and sometimes by a free graft. In approximately three weeks the tube has a sufficiently good linear blood supply to enable one end to be detached from its original site and transplanted into its new position and in a further three weeks the other end can be similarly treated. Throughout the whole process of transference, therefore, the skin and its subjacent tissues are provided with an adequate blood supply and are protected against infection

When the donor area and the recipient areas are far apart, e g in the resurfacing of the neck from the belly an intermediate vehicle to provide a blood supply is necessary In these cases the tube is first attached to the wrist and when it is established in this position it can be carried on the *arm to its new site, whether that be the neck or the foot.* During the various phases of transference some form of fixation is needed to protect the tube against traction or angulation. In most cases elastoplast is all that is required but if absolute immobilization is indicated plaster of Paris is used.

This type of repair often forms the basis for some further surgical reconstruction as *e g* a pedicle derived from the abdomen and carried on the wrist, may provide the soft tissue for the first stage of the reconstruction of a lower jaw resected for carcinoma. The next stage may be the rebuilding

of the bony support by means of a free bone graft. The third stage could be the construction of a buccal sulcus by means of a free skin graft as an inlay to separate the new bone graft from the pedicle in which it was implanted

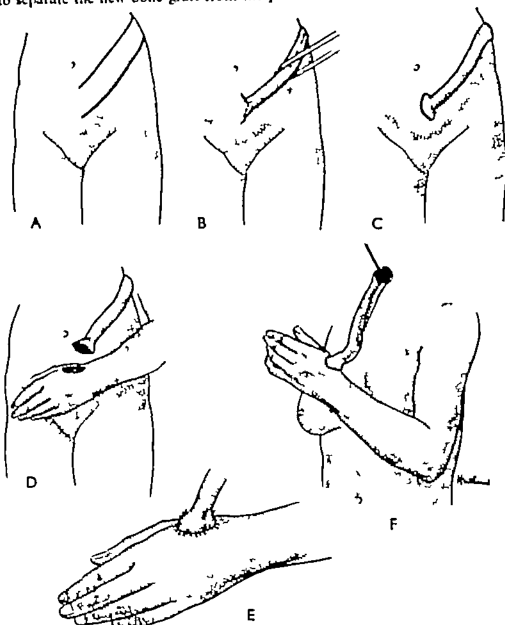


FIG. 40 5 THE TUBED PEDICLE METHOD

A and B show the stages in the formation of the pedicle. In C it has been detached at one end and in D and E it has been prepared and sutured into position on the wrist. In F it has been detached and its other end in preparation for closure of a deficiency elsewhere, e.g. on the face.

The patient would thus have the continuity of the jaw re-established be enabled to wear a denture on the newly built sulcus and might finally be given some motor control of the lip by extending the function of the temporalis muscle to the mouth by the elongation of its tendon by means of a fascial graft.

A repair of such magnitude might well be indicated after the successful

eradication of a cancer after some acute infection such as cancrum oris, after the control of leprous invasion or after the loss of an organ such as the nose from lupus.

Sometimes, of course, the loss of an individual organ such as the nose can be repaired in fewer stages than those outlined.

For example the so-called *Indian method* employs for the reconstruction of the nose a flap of skin from the forehead, and is, for most cases, the method of choice. The flap is more or less pyriform, and has its pedicle based on the supra-orbital vessels. Occasionally the pedicle is so arranged as to contain the superficial temporal vessels. The construction of a nose calls for the supply of lining and framework in addition to covering skin. If sufficient skin for lining is not available on the remnants of the nose it can be provided by the insertion of a mould carrying a double layer of skin, into a pocket beneath that part of the forehead which is destined to provide the skin cover for the new nose. In from four to six weeks the forehead flap can be raised, to carry one of the implanted layers of skin with it as lining for the nose and to leave the other on the frontal area as cover for part of the forehead. When the new nasal tip has been sutured into place the additional raw surface on the forehead created by raising the flap is also covered by a split skin graft.

After fourteen to twenty days the pedicle is divided and the nasal tip finally inset. The remainder of the pedicle is replaced on the forehead after excising part of the graft which has been used as a skin dressing to protect the forehead. If support to the tip is necessary a graft of cartilage or bone is inserted at a later date.

Burns

Extensive burns of any depth will create problems of disturbance of metabolism which are sufficiently urgent to demand early grafting if the patient's life is to be saved. The type of graft used for this primary "skin dressing" is the simplest one possible, *i.e.* split skin. In the more extensive lesions the patient's potential donor sites may be insufficient to provide sufficient skin to give complete cover. It is then permissible to alternate strips of autograft skin with homograft skin. These homografts will persist only for from ten to twenty days, but this may be long enough to ensure the patient's survival and to carry him over until his donor areas are healed and again available as the source of more autografts. The more definitive repairs to restore function and appearance will probably require the use of whole thickness skin grafts or some more complicated procedures. These are undertaken only when primary epithelialization is complete and the patient's survival is assured.

TRAUMATIC LESIONS OF THE FACIAL SKELETON

All facial fractures are almost immediately masked by swelling and they are also difficult to detect by radiographic investigation. There are however few if any which cannot be diagnosed by careful clinical investigation and a routine examination will reveal any important displacements. This examination is best commenced when standing behind and above the patient. The supra-orbital margins are seldom involved and may form the starting point from which the bony points are palpated. Both sides are investigated at the same time to check asymmetry which may be visible or palpable. The fingers are carried along the supra-orbital margins to pass down the outer

wall and along the infra-orbital margins to return to the starting point The most likely places for a fracture line to be encountered are in the outer wall or at the junction of the inner and medial thirds of the infra-orbital margins. The sides of the nose are then examined for asymmetry Next the fingers return to the infra-orbital margin and pass outward along the lower margin of the zygoma to the front of the ears Finally they pass downward along the lower margin of the mandible to the midline.

The position of the examiner then changes so that he faces the patient to note subconjunctival hæmorrhages or squint. The interior of the nose and mouth are best examined with a head mirror or a torch. The nasal mucosa is inspected for tears. The mouth is checked for range of opening and correctness of the bite of the teeth. The mucous membrane of the mouth is investigated for tears or bruising, and finally mobility of the

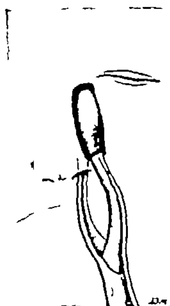


FIG. 40 6. WALSHAM'S FORCEPS FOR RESETTING THE NASAL BONES. The outer blade is covered with rubber to avoid injuring the skin.

maxilla is investigated by gentle pressure on the teeth. When the full investigation is complete there should be few fractures which have escaped detection except those which are not associated with any displacement and which therefore do not warrant treatment.

The commoner lesions will be described separately but may of course occur in combination.

Nasal Fractures. These are usually associated with immediate nasal bleeding. Swelling very soon masks any minor degrees of displacement. Both nasal bones and the septum are commonly involved so that there is external asymmetry and intranasal obstruction

Treatment. This may be deferred for as long as a week to allow swelling to subside and thus to permit accurate palpation as the guide to complete reduction. A general anæsthetic with an endotracheal tube is desirable to protect the patient against the inhalation of blood. Both the septum and the nasal bones are manipulated into their correct position by forceps designed for the purpose. Unless there is gross comminution no fixation is necessary

When the fracture is more extensive and involves the naso-ethmoid area the space between the inner canthi is increased—hypertelorism. This is an appalling deformity and one which it is almost impossible to correct unless the bones are replaced in their correct position almost immediately. The nasal bridge will at the same time have been impacted backward and must be elevated as the first stage in repositioning the fragments. Whilst the nasal bridge is held forward by intranasal forceps, the ethmoid area is compressed very fully by the finger and thumb pressed as far back into the orbits as possible. This compression is maintained by a wire suture which passes through the nasal bones as near the canthi as possible and which is tied over lead plates on the skin surface. These plates are left undisturbed for from two to four weeks.

The treatment of this deformity once it is established is very difficult though something can be done to build up the contour of the depressed nasal bridge by the insertion of a bone graft from the ilium or a cartilage graft from the rib.

Malar zygomatic Fractures. These are recognized by any or all of the following signs and symptoms:

(1) Asymmetry of the cheek bones as observed from above.

(2) The palpation of displacement at the fracture lines which are almost always through the infra-orbital canal, the region of the external angular process of the frontal bone and the zygomatic arch.

(3) Anæsthesia of the lip and the central and lateral tooth on the affected side, due to damage to the infra-orbital nerve in the infra-orbital canal.

(4) Diplopia from interference with the musculature of the eyeball.

(5) Difficulty or pain in opening the mouth caused by pressure of a displaced zygomatic arch on the coronoid process of the mandible or upon the temporalis muscle.

Treatment. Replacement should be carried out early. An incision within the hair line which penetrates through the temporal fascia will allow the passage of an elevator beneath the zygomatic arch. After replacement, the malar is usually stable.

If however the bone is comminuted or is unstable it may be necessary to open the antrum, through the buccal sulcus and pack it with gauze in order to support the fragments in their correct position. Such packing is removed in seven to fourteen days.

Fractures of the Maxilla. These occur as the result of direct injury and are always recognizable by careful examination. The common variants were well classified by Le Fort into three main groups, and it is remarkable how constant these are.

(1) A horizontal fracture above the alveolar ridge separating it from the rest of the maxilla (Le Fort Group I) (Fig. 40.7). If the teeth be carefully moved with one hand no movement is felt to be transmitted to the orbital margins or the nose. The fracture is best seen on a true lateral skiagram.

Any malocclusion must be corrected and the normal bite maintained either by wiring the maxillary teeth to those in the mandible or by obtaining the same fixation by cast silver dental splints.

(2) A fracture line commencing posteriorly in the region of the tuberosity extends obliquely across the anterior surface of the antrum to reach and pass through the infra-orbital notch and thence through the medial wall of the orbit to cross the nasal bones at their bases and extend down a similar path



FIG. 40 7 FRACTURE OF THE MAXILLA GROUP I.

on the opposite side (Le Fort Group II) (Fig. 40 8) The result is to separate the palate and alveolar ridge together with a central pyramid of bone from the rest of the maxillæ This central pyramid is frequently displaced back ward between the malar buttresses. Movement of the teeth also moves the nose and the medial thirds of the infra-orbital ridges Cerebrospinal rhinorrhœa is common. A 30 occipito-mental skiagram shows the displacement

Treatment consists of early reduction under anæsthesia and the maintenance of correct position by fixing the upper to the lower teeth and subsequent support of the combined mandibular and maxillary block to the intact cranium by wires or bars from the dental splint to a plaster of Paris headcap Antibiotic cover will protect against meningitis until the rhinorrhœa ceases This happens spontaneously in most cases, but if it



FIG. 40 8. FRACTURE OF THE MAXILLA GROUP II.



FIG. 40 9 FRACTURE OF THE MAXILLA GROUP III.

should persist for more than ten to twelve days the opinion of a neurosurgeon should be sought.

(3) A fracture line passes horizontally through the external angular processes, the posterior wall of the orbit and the base of the nose to separate the whole facial skeleton from the cranium (Le Fort Group III) (Fig. 40 9). This is a very rare type of fracture causing rhinorrhoea and a disorganized bite which requires treatment similar to those in Group II Lateral and A.P skiagrams are helpful.

None of the fracture lines mentioned above are necessarily only linear They consist more frequently of a zone of comminution. It is not uncommon for reduction of any displacement to be made more difficult by the locking of some of the smaller fragments in such a position as to prevent any movement of the main fragments in relation to each other If this is realized the necessary disimpaction will usually be effective in allowing the displacement to be corrected but it should be appreciated that considerable force may be necessary to effect this disimpaction This is particularly true of the Group II cases in which the central pyramid of bone may be driven back between the intact malar-zygomatic compound and locked there.

Splints or interdental wires should be kept clean by mouth washes and a tooth brush They are usually retained for from three to six weeks by which time union should be sufficiently firm to allow their removal

Complications of Fractures of the Maxilla. *Cerebrospinal Rhinorrhoea.* When the fracture line extends through the cribriform plate cerebrospinal leakage may occur It is seen as a flow of clear or slightly blood-stained fluid from the nose or down the post-pharyngeal wall. In the latter site it may cause the patient to be continually swallowing. The rate of flow can be increased by occlusion of the jugular vein by manual pressure.

There is a risk that infection will spread from the nose to cause meningitis. This is countered by adequate doses of sulphonamide. Early and accurate reduction of the fractures is usually followed by cessation of the discharge. If however the rhinorrhoea persists for more than ten to twelve days the opinion of a neurosurgeon should be sought in case it is felt that a fascial graft should be used to seal the meningeal tear

Aerocele A fracture involving the central areas of the anterior cranial fossa produces as described above, a potential connection between the nose and the interior of the skull Occasionally air is forced through this defect and can become encysted. As a result the frontal lobes are displaced and compressed. The symptoms produced are somewhat vague as no localizing signs are elicited, but the condition should be suspected when within a few days of injury the patient's general state becomes unsatisfactory and he becomes drowsy and develops a temperature without an associated rise in pulse rate. An X-ray picture will clinch the diagnosis. The treatment is to open the air pocket and to seal the meningeal defect causing it.

Diplopia This may follow any fracture which disorganizes the orbital floor It is not clear whether the condition is due to an alteration in space of the position of the eyeball or to ocular muscular imbalance from direct damage. Both factors may be important Spontaneous recovery is unlikely after three weeks and steps should then be taken either to build up the orbital floor by bone grafting or to correct the imbalance by operation on the affected muscles.

Anæsthesia Loss of sensation in half the upper lip and the incisor teeth

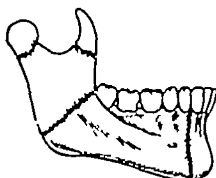


FIG. 40 10. LOWER JAW INDICATING THE MOST COMMON SITES OF FRACTURE

will result from injury to the infra-orbital nerve in its bony canal. It is a very common lesion which may recover within six to eight weeks. Paræsthesia during this period can be troublesome.

Anosmia. Some degree of damage to the fibres of the olfactory nerve is common in any fracture involving the base of the nose and the cribriform area. Recovery is impossible but considerable adaptation occurs.

Epiphora. This will follow damage to or destruction of the naso-lacrimal duct in its passage through the bone. Infection of the sac is prone to occur. Spontaneous recovery is improbable but the results of dacryocystorhinostomy are satisfactory.

Deformity. Comminution of the fronto-ethmoid area will result in the appalling deformity of *hypertelorism*. Its late correction is extremely difficult because of the difficulty of reattaching the internal palpebral ligaments in their correct position. Deformity of the nasal bridge or the malar prominence can be reduced by bone grafting.

Fractures of the Mandible. These are caused by direct violence. Common sites are the neck of the condyle, the region of the canine tooth (a combination



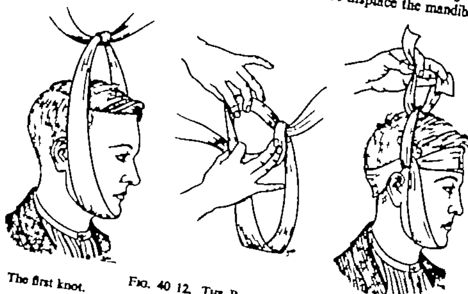
FIG. 40 11 FRACTURE NEAR THE ANGLE OF THE MANDIBLE.

of these is frequently caused by a punch) and the region of the angle. Fractures can, however occur at any point

Signs Displacement at the fracture line results in malocclusion of the teeth and this will be obvious both to the patient and the surgeon. In the tooth bearing area tears or bruises in the mucosa are obvious. Mobility at the fracture line is usually demonstrable. Pain is seldom a marked feature unless the bone ends are unusually mobile or later when infection has occurred This occurs when the fractures are not immobilized early

A P., lateral and lateral oblique skiagrams are useful and dental films will often show the presence of small fragments which tend to obstruct reduction of the fracture

Treatment Immediate support can be obtained by a barrel bandage for which 6 feet of 2 inch bandage is needed A firmly tied bandage exerts upward pressure only (Fig. 40 12) and does not displace the mandible and



The first knot. FIG. 40 12. THE BARREL BANDAGE. Opening out the knot. The finish of the bandage.

tongue backward as will a four-tail. When mandibular fractures are bilateral, tongue control may be lost and there is an ever present risk of death from asphyxia In such a case the patient should be turned on to the face to allow the tongue to fall forward and to permit blood to drain out of the mouth. If the position cannot be maintained a tongue stitch should be inserted and the anterior mandibular fragment drawn forward.

In the definitive reduction of the fracture the teeth are frequently the means whereby fixation is obtained but alternatively skeletal control may be carried out by external pin fixation or by actual wiring or plating of the fracture The latter methods are usually reserved for cases in which there is no lesion of the mucous membrane

Condylar fractures do not require fixation if a normal occlusion is present but if fixation is necessary it should be retained for as short a time as possible (say ten to fourteen days) to avoid trismus following upon the damage to the temporomandibular joint.

In all cases in which the jaws are fixed together either by interdental wires or by splints particular care must be taken to ensure that the diet is

sufficiently high in caloric value and vitamin content In the first few days milk and eggs are the main standby but very soon the patient learns to deal with an almost normal diet. Tube feeding should seldom be needed

The diminished range of tongue movements means that the mouth tends to become foul and this necessitates frequent attention Spray irrigation is later succeeded by the use of the tooth brush.

Complications of Fractures of the Mandible The most serious immediate complication is *asphyxia* as noted above As soon as the bone is satisfactorily splinted the risk disappears

Infection. Infection at the fracture site is very rare even though many of the fractures are compound into the mouth When infection does occur it is almost invariably due to delay in reduction and fixation of the fracture. The infection may well lead to an established non-union but is extremely unlikely to develop into osteomyelitis It can be avoided by early fixation but if it has occurred splintage and adequate external drainage are essential

Established Non-union This is assumed when the fracture line is unstable after nine to ten weeks Skiagrams will show eburnation of the fractured bone ends. Treatment is carried out as soon as the condition is recognized and consists in splintage of the bone fragments in their correct position extensive freshening of the bone ends and the insertion of cancellous bone chips to bridge the defect. Union can be anticipated in five weeks

Mental Anæsthesia This results in embarrassment caused by the loss of sensation in half the lower lip This normally recovers, but even when it persists some overlap occurs and adaptation eliminates the original difficulties.

Trismus Inability to open the mouth can occasionally follow a fracture of the condyle but it probably occurs only when the cranial articular surface of the temporomandibular joint is also damaged. The condition is far more likely to follow an infection in the joint space associated either with a mastoid infection or one of the exanthemata

If the condition occurs in childhood there will be a secondary failure of mandibular development so that the symphysis loses its normal prominence and is deviated to the affected side The contour of the opposite side is also distorted and the dental occlusion disrupted

Treatment consists in wide resection of the affected joint but the procedure should never be undertaken unless facilities are available for post operative dental splinting to control and correct the movement of the mandible in order to ensure functional and dental normality

Dislocation of the Jaw

Dislocation of the Temporomandibular Joint. The usual of type dislocation is *forwards* It results either from muscular action, or from a blow on the chin when the mouth is widely open, as in gaping, laughing, or attempting to take a large bite It has also been produced in dentistry during extraction of teeth, or from digging out roots with an elevator

The *mechanism* of the dislocation is as follows When the mouth is opened, the condyle of the jaw slips forwards on to the eminentia articularis, and it requires very little force to displace it still further into the zygomatic fossa. The interarticular cartilage follows the condyle, and the attachment of the external pterygoid muscle to that structure and to the bone explains the occurrence of dislocation from muscular action.

The displacement may be unilateral or bilateral, more frequently the latter The mouth remains widely open, the teeth and jaws being separated by an interval of about an inch The lower jaw projects and is fixed, saliva dribbling over the lip speech and deglutition are impaired the pronunciation of the labial consonants being especially difficult. A hollow can be detected immediately in front of the tragus, where the condyle is normally lodged, and in front of this the condyle can be felt, being recognized by the slight amount of passive movement still possible. A finger in the mouth may define the coronoid process in an abnormal position beneath the zygoma.

Treatment Reduction is usually easy All that is needed is to depress the condyle below the level of the eminentia articularis, when the masseter, temporal and internal pterygoid muscles speedily draw it back into the glenoid cavity The patient is seated in a chair the surgeon standing in front protects his thumbs with thick swabs, pressing them upon the lower molar teeth Pressure is continued in a downward and backward direction until the condyle is free, and then the chin is raised by the fingers on either side. The jaw is kept at rest for a week or ten days by means of a four-tailed bandage Anaesthesia is occasionally necessary

A few cases are on record of displacement of the condyle of the jaw *backwards* associated with fracture of the tympanic plate and tearing or separation of the cartilage of the auricle leading to bleeding from the ear Displacement *upwards* into the cranial cavity through the roof of the glenoid fossa has also been described

A fracture-dislocation should not be reduced Any attempt to do so is both unnecessary and unrewarding.

CLEFT LIP AND CLEFT PALATE

About one of every seven hundred new born children suffers from a defect in the development of the face of sufficient severity to warrant surgical treatment. The defects are commonly failures of or faults in fusion at one or other of the embryonic fissures or clefts Of these the most important are those which separate the various developmental components of the upper lip and the palate. Abnormalities of fusion of the branchial clefts and of the structures in the various branchial arches themselves do occur but they are relatively less common.

Development of the Face At about the fifth week after conception the primitive buccal cavity is recognizable (Fig. 40 13) It is bounded above by the broad frontonasal process (A) which is separated from the symmetrical laterally placed maxillary processes (B) by a short fissure. Another fissure lies below the maxillary processes and separates them from the mandibular processes (C) which are not as yet fused in the midline. Within the next four weeks all these elements are to develop and merge to form the complicated structures of the face and mouth.

The mandibular processes (Fig. 40 14 E) soon join in the midline to form the lower jaw Developmental anomalies at this point are very rare. The frontonasal process develops a central lobular or internal nasal process (A), which will form part of the central area of the upper lip and the whole of the premaxilla with its contained teeth (Fig. 40 15). It is destined to unite with the lower part of the lateral maxillary process (Fig. 40 14 B) to complete the development of the upper lip and the anterior part of the palate

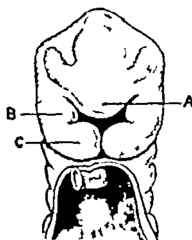


FIG. 40 13 HEAD OF FŒTUS OF ABOUT FIVE WEEKS, FROM VENTRAL ASPECT (*after His*), SHOWING THE PRIMITIVE STOMODÆUM BOUNDED ABOVE BY (A) THE UNDIVIDED FRONTONASAL PROCESS, LATERALLY BY (B) THE MAXILLARY AND BELOW BY (C) THE STILL SEPARATE MANDIBULAR PROCESSES.

The quinque-radiate appearance is well represented.

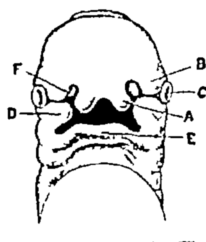


FIG 40 14 HEAD OF FŒTUS OF SIX TO SEVEN WEEKS, FROM THE VENTRAL ASPECT (*after His*).

The mandibular processes (E) have now united the ocular vesicle (C) is seen on either side towards the upper end of the orbitonasal fissure, and the frontonasal process has developed (A) internal and (B) external nasal processes on either side of (F) the still unclosed anterior nares (D) maxillary process.

Obviously a fault in this process of fusion will result in the production of a cleft of the lip or the anterior part of the palate

The lateral part of the frontonasal process (B) is separated from the internal nasal process by a pit (F) which is destined to become the opening of the nostril. This pit is an extension of a deep cleft which has at its upper end the ocular vesicle (C) and which separates the upper parts of the maxillary and lateral nasal processes. Fusion across this cleft completes the development of the cheek and nose and allows the formation of the nasolacrimal apparatus in its depth. Developmental failures here are rare and result in

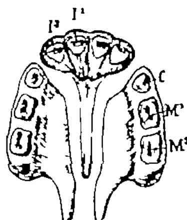


FIG. 40 15 DIAGRAM TO REPRESENT THE SITUATION OF THE CLEFT IN ALVEOLAR HARE-LIP

I 1 Incisors C, canine tooth M¹ M² first and second molars.

abnormalities in the nasolacrimal duct or in the occurrence of an oblique facial cleft.

Fusion between the lip components begins in the floor of the nose and extends downward The process may fail completely or once having commenced, before producing a normal lip may cease. Any partial lesions will involve the lower margin of the lip but not the upper margin. Such lip clefts may be unilateral or bilateral, partial or complete but these differentiations are less important than whether the cleft is confined to the pre-alveolar area or whether it passes through the alveolus.

When it is pre-alveolar it is seldom associated with a palatal lesion. If it involves the lip only it produces a cosmetic and not a functional defect. There will be associated lesions of the nose, the vestibular floor on the affected side will be too wide, the alar base will be placed too far laterally, the alar cartilage will be stretched into an almost straight line instead of being C shaped and the medial crus will be placed posteriorly and caudally in relation to its fellow on the opposite side. The nasal septum will tend to drift to the side away from the cleft and to cause an obliquity of the nose as a whole The degree of deformity will vary considerably being greater in clefts which pass through the alveolus but all the elements described will be present to some extent in any cleft involving the lip

Because there is no functional problem the repair of these defects will be undertaken when the operative risks are at their lowest. This means some time after the nutritional advancement of the child is well established, *i e* the eighth to the twelfth week but delay up to the time of weaning is often desirable.

While the more superficial areas of the face are becoming differentiated the deeper parts of the maxillary and nasal processes are fusing to form the roof of the mouth. In Fig. 40 15 it will be seen that the fusion line is in the form of a Y the centrally placed wedge-shaped premaxilla developing from the deep part of the internal nasal process, while the deep part of the maxillary processes provides the remainder of the hard palate and the alveolar ridge and the whole of the soft palate Fusion between these components commences anteriorly in the region of the alveolar ridge and extends progressively backward to the uvula. A complete failure will produce a lesion similar to that shown in Fig. 40 22 C. but lesser degrees of failure occur as the result of the cessation of fusion after an initial normal commencement. They will obviously result in lesions which involve the posterior parts of the palate and not the anterior parts.

The palatal defect causes an inability to suck and ultimately produces difficulty in speech Its repair is therefore a matter of relative urgency and it is usually desirable to close the defect before serious efforts at speech are made, i.e before the end of the first year

Cleft Lip

An operation for cleft lip is not done unless the hæmoglobin level is normal. Preparation consists solely in the restriction of food intake for four to six hours preceding the anæsthetic. This is particularly necessary when the child s diet consists mainly of milk, as curds may constitute a hazard during the induction of the anæsthetic.

The anæsthetic of choice is nitrous oxide and oxygen with a minimum of ether It is given through an endotracheal tube and additional protection

against the inhalation of blood is provided either by an inflatable cuff on this tube or more usually by the insertion of a pack of moist gauze into the pharynx.

The child is wrapped in a cotton sheet with the arms by the side Care is taken not to produce over heating by layers of woollen blankets or mackintosh sheeting

The technique varies with the type of cleft and with the operator s choice



FIG 40 16. ROSE'S OPERATION FOR SINGLE HARE LIP

On the left side the semilunar incisions are seen extending as far as the free borders of the lip The right-hand figure shows the parts drawn into position the cross-lines represent the silk stitches.

and many variants are possible The simplest type is that applicable to a pre-alveolar cleft. In this condition the lip rests on a normal bony arch and the secondary deformities in the nose are not gross. The amount of tissue available for repair is generally adequate The procedure described by Rose is probably the simplest of all (Fig. 40 16) The margins of the cleft are pared by a curved incision so placed that the vertical height of the lip from the vestibular floor is equal on the two sides. The exposed edge of the orbicu



FIG. 40 17 MIRAULT'S OPERATION FOR SINGLE HARE-LIP

The formation of the prolabial flap is shown ready to be implanted on the prepared inner side.

laris muscle is freed from its attachment to the underlying mucosa and from the overlying skin sufficiently to allow these three layers to be individually repaired. The attachment of the lip to the maxilla is divided especially beneath the alar base on the affected side through an incision in the mucous membrane at its line of reflection in the buccal sulcus.

The components of the lip are accurately approximated by sutures of fine catgut for the mucosa and the muscle and by fine silk for the skin. A modification of this procedure to produce a more satisfactory eversion of the free margin of the lip was devised by Mirault (Fig. 40 17) and this has recently been elaborated by Mesurier The essential point is the utilization

of a small flap from the lateral side of the cleft to re form a Cupid s bow and to reconstitute the central prominence of the free margin of the lip.

Bilateral Pre-alveolar Cleft Lip. In this condition the central prolabial skin is usually well developed and lies in a normal relationship to the



FIG 40 18. ROSE'S OPERATION FOR DOUBLE CLEFT LIP

The central tubercle is pared in a V-shaped manner and the lateral segments by curved incisions, extending to the red margin, and then inwards. Only the apex of the central portion is included in the completed lip

columella. Repair is basically therefore only a matter of repeating a procedure similar to that outlined above on both sides and this is usually carried out in one operation (Fig. 40 18).

These comparatively simple procedures give the most satisfactory results only in clefts which overlie a normal alveolar ridge. Unfortunately clefts



FIG 40 19 UNILATERAL CLEFT LIP ASSOCIATED WITH CLEFT PALATE

of the lip are often associated with clefts of the palate many of which do extend through the alveolar process. When this occurs the premaxilla lies unattached to the maxilla either on one or on both sides. In the former case it will rotate away from the side of the cleft and all semblance of symmetry in the bony foundation of the lip and nose will be lost.

When the cleft is bilateral the premaxilla seldom retains its position as the key stone of the alveolar arch Instead it grows forward on the vomerine

nasal septum and is frequently rotated so that the plane of the prolabial skin is almost horizontal instead of vertical The problem of a definitive repair of the lip is thus immensely more complicated firstly by the need for a preliminary replacement of the bony skeleton on which the lip and the nasal tip would be supported and secondly by the necessity of reconstituting the vestibular floor of the nostrils and the curve of the alar margins

Repair of Unilateral Cleft of the Lip in the presence of an Alveolar Cleft. The width of the cleft will tend to appear excessive because of the rotation of the premaxilla away from the site of the cleft. The first stage of the repair consists in the formation of the floor of the nostril by the suture of a flap of mucoperiosteum based upwards on the septum to a corresponding flap from the lateral nasal wall These flaps are the anterior continuations of flaps which are used for the closure of the hard palate and the operation of



FIG. 40 20 BILATERAL CLEFT LIP AND CLEFT PALATE.

the closure of the lip is frequently only a stage in the closure of the hard palate

When the floor is reconstituted the lip defect is closed by the simplest type of repair in three layers. A truly definitive repair is often undesirable at this stage because of the developmental distortions of the premaxilla and the septum which in turn affects the tip of the nose. The main aim of early operation is the restoration of the integrity of the orbicularis muscle, so that its balanced action will swing the premaxilla back into a more normal position.

Repair of a Bilateral Cleft Lip with Bilateral Alveolar Clefts. As already noted, the premaxilla will have moved forward and rotated out *of alignment* with the alveolar arch. The restoration of muscular tension will correct the forward rotation, but it cannot result in sliding the premaxilla back into its key position in the alveolar arch. If therefore forward rotation is the main displacement, the operation consists of reconstruction of the vestibular floor on each side and the suture of the lateral lip elements to the prolabium. The latter structure does not contain muscle and should apparently take part

in the formation of only that part of the lip which lies at the base of the columella The shortness of the lateral lip elements is, however usually so marked that in the first instance they cannot be sutured to each other and must be attached to the prolabium at least until such time as the pull of the reconstituted muscle has brought the premaxilla back into a more normal position

When, in addition to being rotated forward the premaxilla has grown forward to such an extent that its action as a key in the arch has been lost, simple muscular tension does not correct both elements of the deformity In these circumstances the operation may consist in the closures mentioned above after the premaxilla has been brought back into its correct alignment by a subperiosteal resection of a wedge or bone from the vomer immediately behind the alveolus. This frees the premaxilla and allows it to be repositioned between the anterior ends of the maxillary alveoli It may be maintained in this position by passing a fine stainless steel pin through the centre of the bone to pin it to the stump of the vomerine septum (Matthews). The

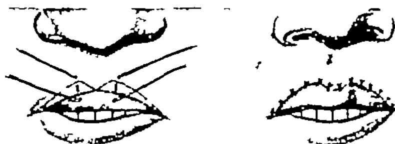


FIG. 40 21 GILLIES'S OPERATION FOR THE FORMATION OF CUPID'S BOW

procedure carries with it some risk both to the blood supply of the premaxilla and to the tooth buds contained within it

Secondary Operations on the Lips and Nose. In all except the most minor clefts, it must be assumed that there is not only a failure of fusion but also some degree of failure of development of the constitutent parts of the lips. In some cases therefore later adjustments are desirable to eliminate or disguise these errors When it has been necessary to incorporate the prolabium in the full vertical extent of the lip at the original operation, the tip of the nose will be flattened by a shortage of the columella At about five years or even later the lip repair is taken down and the prolabial skin advanced to form the columella and to allow the tip of the nose to resume its normal prominence

If the lateral elements of the lip are adequate, they can then be approximated below the newly positioned prolabium However if they are short, this procedure will drag the angles of the mouth towards the midline and create an apparent redundancy of lower lip which habitually will be allowed to lie in the everted position This deformity can be corrected by an Abbe operation A central wedge of all layers of the lower lip is transposed into the defect in the upper lip The viability of the transplanted tissue is maintained by a small pedicle carrying an intact labial artery and vein from one side only This little pedicle interferes but little with feeding and can be

divided in ten to fourteen days, by which time a sufficiently satisfactory local blood supply is available to the transplanted wedge of lower lip

A lesser degree of deficiency will result in a lip which is a little too flat It is often adherent to the premaxilla with loss of the buccal sulcus. Since the dental state is usually defective in these cases, it may be desirable at a later date to remove some of the anterior teeth and replace them by a small prosthesis, providing both dental competence and an improved appearance If the lip remains adherent to the premaxilla this is impossible and it may therefore be desirable to free the lip and epithelialize the raw surface so created on the alveolus and on the posterior surface of the lip by a skin graft inlay Space is thus created for the fitting of a dental prosthesis which not only disguises the dental defects but supports the lip in a normal relationship to the rest of the face At the same time minor irregularities in the mucocutaneous line can also be corrected as illustrated in Fig. 40 21

It will be appreciated therefore that responsibility for the patient only commences with the first operation and must continue until his development is complete, so that minor errors and faults can be corrected when it becomes obvious that they will not improve spontaneously

Cleft Palate

An outline of the embryological development of the palate has already been given. The origin of the various types of cleft commonly encountered should therefore be clear from a consideration of Fig. 40 15

In all cases where there is a cleft of the palate there is dysfunction and for this reason early operation is necessary whether or not the cleft of the palate is associated with a cleft of the lip

The dysfunction arises from an inability to separate the nose from the mouth. Sucking therefore is impossible and in due time speech will be abnormal. Continued exposure of the nasal mucosa to food will cause an hypertrophic rhinitis with possible involvement of the pharyngotympanic (Eustachian) tube and the middle ear

The aim of operation is to create a barrier between the nose and the mouth, the posterior part of this barrier to consist of a normal or almost normal muscular velum capable of approximation to the posterior pharyngeal wall to form an active oronasal valve All the modern operations therefore are designed to elongate the palate in the process of closing the defect. As in the case of the lip it is often found that the amount of material available to effect closure of the palate is insufficient. As a result the required palate may tend to be too short to reach the posterior pharyngeal wall In these cases secondary procedures may well be indicated in an endeavour to construct a functional mechanism capable of closing the nose off from the mouth.

Defect in the Soft Palate only This is usually capable of efficient closure to create sufficient length of repaired palate to ensure that it reaches the posterior pharyngeal wall whilst still retaining the necessary mobility to allow of normality of speech. The construction of an efficient muscular velum is the essential part of any operation or series of operations, designed to close palatal defects and it will therefore be considered first.

The time of operation is arranged so that completion of all the necessary stages is obtained before serious endeavours to speak are made, i.e. before the end of the first year If therefore the repair can be completed in one operative stage there is no real urgency in undertaking it, but if as is the

case say in a complete bilateral cleft of the lip and palate, more than one stage is needed the first operation should then be undertaken at or about three months.

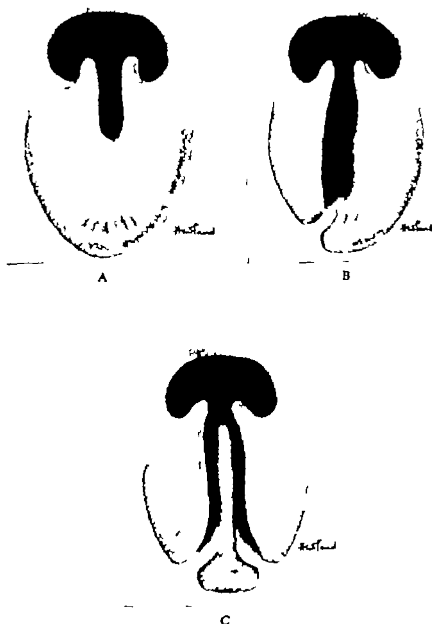


FIG. 40 22. VARIOUS FORMS OF CLEFT PALATE.

A. INVOLVING ONLY THE VELUM.
B. TRAVERSING THE HARD PALATE AND THE ALVEOLUS.
C. COMPLETE BILATERAL CLEFT SEPARATING THE PREMAXILLA AND THE SEPTUM FROM ALL ATTACHMENT TO THE MAXILLÆ

B and C are almost always associated with a cleft in the lip The figures are drawn in the position in which the surgeon sees the palate when operating.

The preparation for the operation and the type of anæsthetic used is similar to that employed in repairing a cleft lip

The Repair of a Cleft of the Soft Palate (1) The margins of the defect are pared or split to divide the velum into two layers.

(2) An *incision is made through the mucoperiosteum of the hard palate* commencing at the anterior end of the cleft running forward and outward to the alveolar ridge where it meets a longer incision extending from well behind the tuberosity forward just medial to the alveolar ridge.

(3) The resultant flaps are raised from the bony hard palate and freed from its posterior margin. The posterior palatine vessels are preserved but the soft tissue attachments laterally to the tuberosity and the hamulus and *to the internal pterygoid plate are extensively freed* The hamulus is fractured to eliminate the tightening action of the tensor palati The nasal

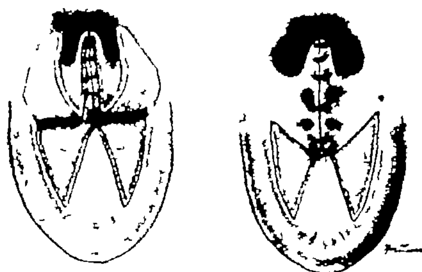


FIG. 40 23 THE TWO STAGES IN THE REPAIR OF A CLEFT INVOLVING [illegible] PALATE.

mucous membrane is dissected free from the upper surface of the [illegible] part of the bony hard palate.

(4) The resultant flaps can be rotated backward and medially [illegible] of the nasal mucosa. They are sutured together with fine catgut [illegible] anterior ends are fixed to the remaining triangle of hard palate. [illegible] raw surfaces so created are covered by a pack of ½ inch gauze, [illegible] in Whitehead's varnish.

To ensure adequate control of the tongue in the immediate [illegible] phase, a heavy silk stitch is passed through it and brought out [illegible] to be fixed to the cheek by adhesive plaster The pharyngeal [illegible] and the pharynx carefully aspirated of all blood and mucus [illegible] turned *into the semi-prone position* and is kept in this position [illegible] from anæsthesia.

Very little sedation is found to be necessary No post-[illegible] dietetic restriction is needed but it is advisable to follow each meal [illegible] drink [illegible]

water in order to limit the accumulation of food debris on the palat must not be forgotten that as the result of the operation the palate i the time being relatively immobile

The packs inserted in the palate at the time of operation are rem at the end of a week, no anæsthetic being necessary The residual raw sur are usually healed within a further three or four days

The Repair of a Cleft Involving the Hard Palate When the defect ex forward to involve the hard palate and to pass through the alveolus on or both sides it is usual to repair the anterior part of the palate together the lip defect as a preliminary procedure. This converts the lesion into a



FIG 40 24 THE STAGES IN THE REPAIR OF A CLEFT INVOLVING BOTH SOFT AND H PALATES.

The nasal floor is reconstructed by a flap from the septum which is joined to a fla mucosa from the nasal floor The flaps of oral mucosa are swung together and jo in the middle line, both to each other and to the reconstituted nasal lining.

involving the soft palate only so that the subsequent repair underta some months later can be carried out as outlined above.

In other words the first operation provides the foundation upon wh the movable velum is later to be reconstructed. The stages in the repair as follows

(1) An incision commencing posteriorly at the tuberosity and just me to it extends forward skirting the inner margin of the alveolus unti reaches the edge of the cleft At this point it turns back to the poste margin of the hard palate along the margin of the cleft The palatal mu periosteal flap is raised and remains attached only posteriorly The h zontal plate of the maxilla is thus exposed and starting from its poste medial angle one can elevate the nasal mucous membrane from the n floor

(2) On the medial side of the cleft an incision is made in the mu perichondrium of the nasal septum and a flap raised

(3) These two flaps therefore reconstitute the floor of the nose and

procedure is continued through the cleft in the alveolus to re form the floor of the nostril (see repair of the cleft lip)

(4) The oral flaps of mucoperiosteum are approximated *in the midline* or if there be only one it be swung to the midline and sutured to the recon stituted nasal floor by one or two mattress sutures of catgut

(5) The lateral raw surfaces are covered with ½ inch gauze in Whitehead s varnish.

The post-operative care is the same as in any other palatal operation When the cleft is bilateral (Fig. 40 22 C) the reconstruction of the hard palate is carried out on both sides at the same time

As already noted, this operation merely provides the foundation upon which a moveable soft palate can be created later by the procedures given above

Secondary Operations to improve Palatal Function. There are occasions

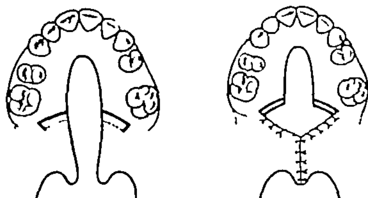


FIG. 40 25 THE GILLIES-FRY OPERATION FOR A SHORT CLEFT PALATE.

In the former the necessary incisions are indicated In the latter the method of bringing the flaps together is shown, so as to provide an effective velum the opening in front is covered over by an artificial obturator When the cleft has already been closed to produce too short a palate only the transverse incision is needed.

when the surgeon encounters an already repaired palate which is lacking in mobility and which does not reach the pharyngeal wall Speech will be defective and food may escape into the nose. An endeavour may be made to push the remnants of the soft palate back even at the expense of the creation of a defect in the hard palate. The Gillies-Fry operation (Fig. 40.25) is designed to use all the remaining muscular elements for their correct purpose A recent modification consists in the closure of the resultant anterior palatal defect not by a dental plate but by introducing a pedicle and skin and fat to reconstruct the hard palate.

An alternative or a complementary procedure is *pharyngoplasty* by which an excessively capacious nasopharyngeal opening may be reduced both in width and antero-posterior distance, so that the palate though it remains short may now reach the pharyngeal wall in its new position and thus effect the closure between the mouth and the nose. Various methods have been suggested Hynes employs two broad flaps of mucosa and muscle from the lateral pharyngeal wall. These flaps are based upward and are subsequently transposed to lie horizontally The closure of their donor areas narrows the pharynx and the ridge they make by their imbrication brings the posterior wall further forward.

Others have used centrally placed vertical flaps of mucosa and muscle raised from the posterior pharyngeal wall to be swung forward and attached to the short hard palate. This method seems unphysiological as it appears that it ought to tend to limit still further the movement of the palate but it is said nevertheless to be effective.

Complications of Operations for Cleft Lip or Palate. These are few. The most obvious one is infection, but this is a rarity if care is taken to avoid operating when streptococci are shown in any numbers in a pre-operative throat swab. Care must also be taken that the child's visitors for the first three or four days are carefully screened and that no one is admitted suffering from sore throats or colds.

Laryngotracheal Œdema. This can occur and may be the result of a minor degree of trauma during the insertion of the endotracheal tube. Increasing respiratory obstruction is rapid and commences very soon after operation. A stridor is first noted. Early tracheotomy is essential.

These risks are not primarily risks of an operation on the palate. They are primarily risks associated with the giving of an anesthetic to a small child.

Other Facial Deformities

Faults of development can occur at other fusion lines, as for example that between the mandibular and the maxillary processes. This will produce a condition of macrostoma, as shown in Fig. 40 26.



FIG. 40 26. MACROSTOMA WITH AURICULAR APPENDAGES.

Abnormalities may arise in Meckel's cartilage resulting in the absence of the major part of the ascending ramus and the condylar head of the mandible. Considerable facial asymmetry will develop but it is probable that the maxilla is involved only secondarily. This being so there is a tendency nowadays for operations to lengthen or replace the deficient ascending ramus of the jaw to be undertaken much earlier than hitherto. The associated deformity of the external ear and the auditory meatus may also demand treatment.

ABNORMALITIES OF THE BREAST

These abnormalities may vary from an amastia either unilateral (*Fig. 35 2*) or bilateral to gross hypertrophy of the type shown in Fig. 35 3

When the breast is absent it is not uncommon to find an associated deficiency of the pectoralis major As a result of this the chest wall remains concave unless the inversion of the ribs is corrected by surgery Reconstruction of the breast is possible by importing skin and subcutaneous tissue from elsewhere but it is justified mainly in the unilateral cases

Diffuse Hypertrophy of the Breast Reference to this condition is made in Chapter 35 where it is also illustrated There is a general enlargement of the organ, usually bilateral and chiefly of the fibrous stroma and fatty tissue. The breasts may reach enormous dimensions

The condition occurs at puberty and is presumably due to œstrogenic over-stimulation Occasionally it may follow pregnancy or interrupted lactation The breasts are at first painless, but with the passage of years pain occurs in the neck and shoulder girdle, caused by their considerable weight. The main symptoms are psychological and this is easy to understand for the bulk and weight of the breasts cause both physical and mental distress to the patient.

Treatment It is not generally appreciated either by the laity or by many doctors that reduction in the size of the breasts may be satisfactorily carried out without unsexing the patient. There is, of course, no justification at all for a bilateral amputation Treatment by hormones is not likely to be of benefit, so operation is the only effective method

Many operations have been devised but only two are practised to any extent. That devised by Biesenberger is illustrated in Fig. 40.27 The principle consists in excising the two outer quadrants of the breast while retaining the blood supply to the two inner quadrants and the areolar area. After removal of a periareolar strip of skin, the skin is undercut and the breast tissue freed by swab dissection from the skin and muscles, particular care being taken to preserve the branches of the internal mammary artery The outer quadrants are excised with a long S-shaped incision so that the lower pole of the breast can be turned upwards and fixed with deep catgut sutures to the region of the axillary tail In this way the nipple is also raised There now remains an excess of skin and subcutaneous fat in the lower part of the wound which is trimmed and sutured horizontally A slight disadvantage is the vertical scar which runs down from the nipple over the surface of the breast.

The other method consists in making a circular hole in the skin over the upper part of the breast and transferring the nipple and areola to this subcutaneously The lower half of the breast is then excised through a transverse incision. When no consideration need be given to future lactation (which in any case is seldom at all satisfactory in cases of diffuse hypertrophy of the breast) the operation may be simplified by free grafting of the nipple

There would appear to be no justification for deferring operation since the hypertrophy is primary occurs as a rule at puberty and does not tend to improve The distress which the established condition causes makes early operation highly desirable and there is no suggestion that it has any bearing on the possibility of later neoplastic change. The effect on lactation has already been mentioned and need not really be taken into consideration.

Replacement of the Breast. There are occasions when it may be desirable

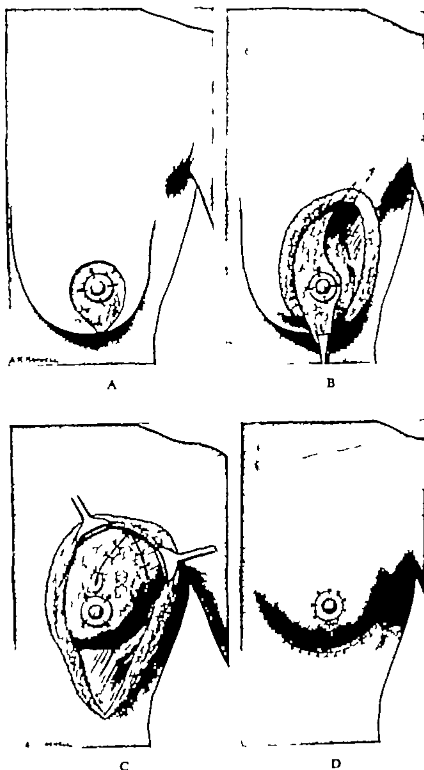


Fig. 40 27 Mammaplasty

A Periareolar Skin Strip Removed
B Outer Quadrants Removed by "S"-shaped Incision
C Reconstruction of the Breast
D Final Result of Mammaplasty

to try and fashion a new breast Congenital absence is clearly one of these The development of the breast may be interfered with by surgery in childhood or as sometimes happens, by the treatment of a nævus by radiotherapy Following a local or radical mastectomy for malignant disease it may be justifiable to replace the breast

A new organ may be formed from the skin and fat of the abdominal wall a long tubed pedicle being fashioned, based in the mid axillary line The umbilicus, turned inside out and supported by a piece of cartilage forms the nipple. The resulting " breast " has obvious attractions compared with a prosthesis.

Chapter 41

THE SURGERY OF TROPICAL DISEASES

Introduction

Tropical surgery is a non-existent specialty The greater part of surgical practice in tropical countries consists in the treatment of the same maladies which occupy the surgeon's time in temperate climates. A very small proportion of time is spent dealing with pathological conditions peculiar to the tropics, and even these maladies are occasionally encountered elsewhere. In tropical practice however there is frequently a different distribution of disease incidence although with the wider spread of adequate medical facilities it is now becoming realized that lesions once thought to be uncommon are in fact seen not infrequently Among these, for example, are peptic ulceration and acute appendicitis.

There are however many pathological conditions which while not found exclusively in tropical countries are much more common there than elsewhere In the ætiology of some of these temperature and humidity play a part but almost all are due to infection or infestation with organisms or parasites which invade the body as a result of defective sanitation or unsatisfactory eating, working or living conditions. Furthermore whereas in practice in temperate climates one is taught to seek a single pathological basis for every patient's illness, in tropical practice one must expect to encounter multiple pathological conditions in the majority of patients. The patient admitted for treatment of an inguinal hernia will almost certainly be suffering from intestinal helminthiasis, is likely to have dormant malaria, will probably be also anæmic and hypoproteinæmic and may well have some fungal infection of the skin of toes and groin.

Some parasitic conditions are peculiar to certain areas. *Clonorchis sinensis* is found in South East Asia and affects principally the Chinese race because of their dietary habits. It produces cholangiohepatitis, and biliary cirrhosis and may predispose to cholangioma. Paragonimiasis is seen most frequently in Indonesia while the guinea worm and loa loa are peculiar to West Africa.

Some lesions such as primary carcinoma of the liver can scarcely be called tropical in character and yet they are seen much more frequently in certain races living in warm areas, than in others The only obvious connection is the frequent occurrence of cirrhosis of the liver in young people It is particularly common in South East Asia and in Central and South Africa

Other lesions may be described as tropical merely because they arise as a result of habits and customs of the people who live in the tropics. Examples of these are the " betel " nut carcinoma of the cheek and alveolus arising as a result of chewing betel, the Kangri cancer of Kashmir and the Kang cancer of North China, both arising as a result of chronic burns of the skin

Some conditions are found much more frequently in certain races than

others and yet climatic factors or personal characteristics do not appear to explain the high incidence One of these the nasopharyngeal carcinoma is so common among the people of South China that it is known as the Canton tumour and is a very common cause of enlarged cervical lymph nodes.

More important perhaps than the peculiar diseases encountered among tropical peoples are certain general considerations which must be taken into account in practice High temperatures produce sweating and this in its turn, damp-sodden wounds which are more liable to infection Minimum dressings consistent with adequate protection are necessary Minor skin infections both fungal and bacterial are particularly prevalent in the tropics and pre dispose towards wound infections. High temperatures produce excessive fluid loss which requires even more careful attention to fluid balance than is usual in temperate climates.

A final caution must be mentioned in relation to tropical surgery In the majority of tropical countries, life is still a struggle which must be waged by every individual Medical treatment must be aimed not merely at restor ing the patient to health but at restoring him to such full health that he is capable of earning his own living. At the risk of being thought too con servative the surgeon should remember that operations which cure a disease but leave the patient a chronic invalid are of little value The time may come when ultra radical resections for carcinoma are justified everywhere, but at the present time the criterion for surgical intervention should be "Can the patient be restored to full working capacity?" If the answer to this question is "No" surgery is rarely justifiable In this connection it is desirable also to make full use of facilities for rehabilitation The depart ments of physical and occupational therapy are still relatively underdeveloped in most tropical countries although the need for them is even greater there than in more highly civilized areas.

Fluid Requirements. The fluid requirements of the patient have become better understood in temperate climates but the understanding of fluid balance in tropical climates is not yet fully accomplished. A patient must sweat to lose heat and failure to do so will induce hyperpyrexia. The failure to evaporate sweat will also cause hyperpyrexia and increased sweating. In hot weather therefore, excessive coverings must be avoided and in most cases the use of a heat cradle is better avoided Similarly the use of atropine as premedication is potentially dangerous as it inhibits sweating and en courages hyperpyrexia. In a few hospitals, air-conditioned rooms are available for the immediate post-operative periods when fluid losses tend to be considerable and their replacement difficult, but unfortunately in the majority of hospitals air-conditioned rooms are not yet available.

It should be assumed that every patient who goes to the operating room for a major procedure in hot weather will require more fluid in the first twenty four hours than he can safely take by mouth. This may not be true for herniotomy or other similar operations, but it is certainly true for every operation on the bowel or for any patient who is pyrexial. Provided that the patient is normally hydrated beforehand a simple rule which works in practice is to give 3 litres of fluid in the first twenty-four hours intravenously of which 1 litre should be normal saline and the remainder 5 per cent. glucose. In very hot weather the amount should be increased to 4 litres but saline should not exceed 1 litre. It is far better to use this method and to a large extent prevent dehydration than attempt to correct it afterwards

Blood Requirements. Whereas in most temperate climates the average hæmoglobin level of patients entering hospital does not differ seriously from normal, the position is very different in the tropics where continual intestinal infestation plus malaria and malnutrition produce an almost universal anæmia. It has been suggested that the average normal is in fact lower among tropical peoples, but this is probably not so for after eradication of infestation and adequate feeding it is almost always possible to raise the hæmoglobin to a level regarded as normal elsewhere (14 g./100 ml.).

Low hæmoglobin levels mean that patients stand operation less well and blood transfusion may be required more frequently than is the case in practice elsewhere It also adds difficulties in the way of transfusion for it may be difficult to find donors among the local population who not only are willing to give blood, but have a hæmoglobin level sufficiently high to justify the donation. Transfusion from a donor who has only 10 g. Hb /100 ml. may be satisfactory to replace blood lost at operation, but it will not raise the overall level of the recipient s hæmoglobin above the same 10 g. A further point bearing on the low hæmoglobin level is in relation to anæsthesia. Anoxia must be carefully guarded against for the patient has less than normal oxygen carrying capacity Every attempt should be made to prevent an excessive fall in blood pressure and impaired circulation and if hypotensive anæsthesia is used at all, it must be administered with very great care.

Special Complications of Surgical Procedures in the Tropics. It is not uncommon for surgical intervention in the tropics to precipitate an attack of malaria, but this is particularly liable to occur after any operation in the upper abdomen where spleen and liver are handled Not infrequently it is seen after splenectomy The cause is undoubtedly the mobilization of parasites dormant in the liver and spleen and the attack occurs characteristically seven to fourteen days following operation. It is relatively unusual for it to present as a typical intermittent fever with rigors and more common for it to show as a low grade continuous pyrexia It may sometimes be suspected when fever exists without much elevation of the leucocyte count and parasites should be sought for in the blood. In the absence of an obvious cause for pyrexia even if parasites cannot be found a therapeutic test with antimalarial drugs is justified.

Much rarer is the attack of hæmoglobinuria following surgery in a malarial subject. Its cause is uncertain and when it occurs it does not usually persist long, although it may be accompanied temporarily by oliguria as in blackwater fever

Diseases of the Gastro-intestinal Tract

Dysentery *Bacillary dysentery* This is of little surgical significance for although exceedingly prevalent throughout the tropics it rarely leads to perforation or stricture and it never produces a palpable mass.

Amœbic dysentery This condition on the other hand may do all three of these Perforation occurs relatively infrequently but when it does it produces general peritonitis with a minimum amount of adhesions. The patient presents as an acute emergency and does not necessarily give a history of dysentery The diagnosis can rarely be made with certainty although it may be suspected when a case of perforation occurs in the absence of a history of peptic ulceration and not obviously in the course of a febrile

illness such as typhoid fever In most cases at laparotomy there is a particularly foul peritonitis and the perforation may be hard to find When found the latter may be closed in the usual way but the wall of the intestine is friable and sutures may not hold. In such cases it may be patched with omentum, or an *appendix epiploica*, or if the perforation is very large the bowel may be exteriorized as a colostomy for closure later Resection is rarely indicated.

Stricture occurs less commonly than perforation and when it occurs it is difficult to demonstrate with certainty the exact ætiology It presents as a chronic obstruction which may be treated by resection or anastomosis.

Amœboma is the most important local surgical complication of amœbiasis for it produces a mass in the cæcum or the rectum which closely mimics a carcinoma In most cases the development of an amœboma may be regarded as the result of high host resistance with low organism virulence Symptoms of dysentery are often minimal With a mass in the right iliac fossa there is local pain and some central abdominal colic the result of obstruction of ileum or appendix. In the rectum the amœboma produces pain and tenesmus with blood and mucus in the stools On examination the rectal growth may be felt as a firm friable mass usually relatively mobile for its size, although it may spread into pararectal tissue The cæcal lesion produces an ill-defined mass in the right iliac fossa slightly tender and indistinguishable from a carcinoma or hypertrophic tuberculosis or a very chronic appendix mass

The diagnosis can be suspected by finding amœbæ or cysts in the stools and in the case of a rectal lesion can be confirmed by biopsy The cæcal lesion shows as an irregular filling defect in the barium enema but this is not diagnostic. Fortunately amœbomata are usually very sensitive to emetine and after ten days treatment are much reduced in size. This therapeutic test is valuable especially in cæcal lesions, and a negative test should always be followed by exploration. Resection of bowel infected by amœbæ may be followed by amœbic digestion of the wound if there is contamination, but it can always be prevented or easily cured by the use of emetine.

Schistosomiasis. This disease occurs as a result of infestation with *Schistosoma mansoni* or *Schistosoma japonicum* Both lesions affect the rectum and sigmoid colon particularly and are liable to produce a mass with ulceration. The symptoms are those of obstruction with intermittent diarrhœa and blood in the stools, and generally mimic a carcinoma. Bleeding and the discharge of mucus are less profuse than in either carcinoma or amœboma but the differentiation from the former is only made with difficulty The latter however presents little difficulty on account of the rather florid mass which may be seen per rectum

Treatment is unsatisfactory for there is no means of causing *resolution* of the fibrous stricture which results from the disease, and resection should be carried out if practicable. If on account of extensive fibrosis around the mass resection is impossible a palliative colostomy is indicated.

Ascariasis. *This condition* is almost universal and infestation is frequently very heavy Worms may be passed per rectum or vomited They may find their way through a perforation of the stomach, duodenum or appendix and may by their vigorous movements initiate perforation in bowel which is already damaged by typhoid or dysentery Not infrequently

they migrate into the common bile duct where they produce colic and inflammatory changes and occasionally obstructive jaundice The most important complication, however is that by the very number of worms present they may produce intestinal obstruction. It is highly desirable to examine the stools for ascaris and other infestation before every abdominal operation



FIG. 41 1 CHOLANGIOGRAM SHOWING ASCARIS IN THE COMMON BILE DUCT

involving the bowel for live ascaris are quite capable of finding a suture line and "worming" their way through to the peritoneum with consequent peritonitis.

The majority of other parasites are of no surgical significance except in so far as they produce debilitating effects on the patient Cannon however



FIG. 41 2. ARMILLIFER ARMILLATUS.

Transverse section of the colon, showing the grossly thickened mesentery and bowel-wall studded with encysted nymphal forms, and the almost complete obstruction of the lumen of the bowel.

has described an instance of infestation with *Armillifer armillatus* producing severe intestinal obstruction The diagnosis might be made by seeing the characteristic calcified crescentic shadows radiologically but it is only in the late stages when parasites are dead that calcification occurs.

Diseases of the Liver, Biliary Tract and Spleen

Liver Abscess

The lesion occurs in two main forms due to (*a*) amœbic infestation and (*b*) pyogenic organisms. Neither is very common but both are seen more frequently in tropical practice than in temperate climates.

Amœbic Abscess. This may be a complication of intestinal amœbiasis and may occur during an exacerbation of the intestinal lesion or after the latter has been quiescent for months and years. It occurs at any age but is unusual in young people For reasons which are not clear more cases are seen in men than women The onset is usually gradual with progressive pain in the right upper quadrant accompanied by considerable pyrexia, and sometimes rigors.

Physical Signs The liver is enlarged although in the early stages of amœbic hepatitis this is not very noticeable There is tenderness and often guarding or rigidity over the edge of the liver and sometimes tenderness in the intercostal spaces over the liver Very occasionally there is no down ward enlargement but the abscess points upwards and causes elevation and immobility of the diaphragm Untreated the abscess will usually con tinue to enlarge and burst either through the skin or if pointing upwards, through the diaphragm In the latter event the two layers of the pleura are usually adherent and the abscess continues to enlarge into the lung until it bursts into a bronchus. In the author s experience, however the majority of abscesses enlarge downwards The condition has to be differ entiated from pyogenic liver abscess and from acute cholecystitis and cholangiohepatitis. Jaundice is rarely present

Treatment Amœbic hepatitis responds to emetine injections intra muscularly but by the time an abscess has formed the pus must be evacuated In the past open drainage has had an unenviable reputation but with the advent of chemotherapeutic control of infection it has become safer Never theless, aspiration should first be attempted using a very wide bore needle. The liver is explored with a needle where the abscess seems closest to the surface, and the pus completely evacuated if possible. Emetine gr 1 2 (60–120 mg.) is then left in the cavity Aspiration frequently requires to be repeated. On many occasions the pus will be too thick to evacuate easily and in those cases no time should be lost before open drainage is instituted. The cavity is opened and washed out with hydrogen peroxide and eusol and daily washouts continued until the discharge is decreased. If the discharge does not clear rapidly after washing out with saline or water streptokinase can be instilled into the cavity for several successive days and this will often facilitate healing. In any case a full course of emetine intramuscularly must be given, and steps taken to eradicate any persistent bowel infection.

Pyogenic Abscess. This is a definite recognizable clinical entity capable of being accurately diagnosed provided that the possibility is kept in mind. The organisms responsible are most frequently those of the gastro-intestinal

tract and the infection in most cases comes from the portal system. In a few instances *Staphylococcus aureus* and hæmolytic streptococci have been isolated while in many recorded cases the contents were sterile. In most cases the onset is insidious with pyrexia and general malaise Rigors are common and pain appears after a few days but is not constant The pain is usually dull and epigastric but occasionally intercostal pain is experienced. Respiratory symptoms, dyspnœa, hiccough and a dry cough are fairly common. Radiologically the diaphragm may be immobile and sometimes displaced upwards. Leucocytosis is usually well marked, often 25 000 cells per cu. mm or more. The differential diagnosis is from amœbic abscess, multiple abscesses and primary carcinoma of the liver a condition seen commonly in many tropical areas and also producing a large tender mass with pyrexia and leucocytosis.

Treatment This may be either by open drainage or closed aspiration with air replacement The former was usually advised because of the risk of contaminating either pleura or peritoneum but with the advent of efficient chemotherapy closed drainage is much safer than before Air replacement will to some extent prevent the walls of the abscess collapsing and bleeding. Penicillin and streptomycin in saline are introduced directly into the cavity and healing may be expected to occur fairly quickly Repeated aspiration however is necessary in these cases and the size of the cavity may be estimated radiologically from the shadow produced by the air introduced or by Lipiodol.

Cholangiohepatitis. This disease occurs with far greater frequency among Chinese in South-east Asia than among other people and in other areas It is of great surgical importance for it produces an acute abdominal emergency with severe pain pyrexia, guarding and rigidity and a palpable gall-bladder which is often grossly distended. The ætiology is uncertain. It is infective in origin and the infection reaches the biliary tree *via* the



FIG. 41 3 CALCULI EVACUATED FROM THE COMMON BILE DUCT AND ITS TRIBUTARIES ARRANGED APPROXIMATELY AS FOUND AT OPERATION.

portal system and bile The organisms commonly found are *Esch coli* and *Str fæcalis* The reason for the epidemiology is hard to find and the only feature peculiar to these people and their area is infestation with *Clonorchis sinensis* (the Chinese liver fluke) which is found in a very high proportion of the population (35–70 per cent) Nevertheless it is not invariably found in patients with acute cholangiohepatitis In these cases the flukes may have been present and died

Pathology The common bile duct is dilated and contains biliary mud pus, adult clonorchis, stones and bile and occasionally other parasites The wall is thickened and œdematous. Stones may often be found high up in the intrahepatic ducts and may predispose towards carcinoma of the bile ducts. In the late stages the liver becomes honeycombed with abscesses which coalesce and may point and burst superficially The gall bladder is thin-walled, distended contains bile mucus and very occasionally stones. There is no doubt that the pathology is not primarily in the gall bladder and stones if present in the common bile duct have formed there and not in the gall bladder

Diagnosis This is not difficult if one is aware of the condition but treatment is extremely difficult Untreated the patient gets recurrent attacks of pain and jaundice and may occasionally succumb to a ruptured gall bladder or eventually to liver failure

Treatment The biliary tree requires drainage Choledochotomy evacuation of stones and T tube drainage are satisfactory temporarily but the condition almost always recurs and eventually is fatal The use of the gall-bladder for drainage is also unsatisfactory as the cystic duct becomes blocked at its junction with the common bile duct and eventually fails to decompress the biliary tree. The most satisfactory results are obtained by choledochoduodenostomy which may be done as an emergency operation immediately after opening and cleaning out all debris from the ducts or as a secondary procedure after preliminary drainage.

Primary Carcinoma of the Liver Malignant hepatoma is another peculiarity which, while not associated with climatic conditions, is seen more frequently in certain tropical countries than elsewhere. The common type (hepatoma) is usually grafted on a pre-existing cirrhosis perhaps of nutritional origin In most cases the first complaint is either general malaise or the presence of an abdominal tumour There is loss of weight, low grade pyrexia, anæmia and often a subclinical jaundice becoming clinically manifest in the later stages. Evidence of portal hypertension is frequently present with splenomegaly and dilated œsophageal varices which may bleed. Ascites may be due to this cause or to involvement of the peritoneum by the disease The disease may metastasize involving nodes in the portal fissure and less commonly producing secondary deposits in lungs and bone. Death usually occurs from liver failure The disease is of little surgical significance except as a problem in differential diagnosis, but occasionally large solitary carcinomata of the left lobe have been resected, with temporary benefit to the patient. The cancer is however often multicentric in origin and recurs rapidly

The less common variety (*cholangioma*) arises from bile duct epithelium and may be the result of chronic irritation and inflammation as occurs in cholangiohepatitis. An intrahepatic stone may become surrounded by carcinomatous tissue Growth in these cases is often slower than in hepatoma

The relief of the various secondary effects of this serious affection demands operative measures for calculi perineal fistulæ etc.

Granuloma Inguinale (*Ulcerating Granuloma of the Pudenda*) This is an infectious granulomatous condition of the pudenda, which is conveyed by sexual intercourse as well as by auto-inoculation. This disease is well known in India South China, West Africa North Australia New Guinea the Pacific Islands, South America and the West Indies. The cause is *Donorania granulomatis* A secondary invader in the ulcerations is a non-hæmolytic anaerobic streptococcus.

Pathology The disease is allied to rhinoscleroma The growth is formed of masses of nodules consisting of round cells with large nuclei. Though vascular these growths contain no hæmorrhages In vertical sections the cell-masses are wedge-shaped, with the base being directed towards the surface

Ulcerating granuloma does not occur before the age of puberty It is found from thirteen or fourteen up to forty or fifty years of age, and in both sexes, but more frequently in women.

The normal incubation period is from two to eight days but may be as long as twelve weeks In most cases the ulceration commences on the genitalia, on the penis or labia minora or in the groin. Beginning as a nodular thickening of the skin, it excoriates and eventually ulcerates spreading by peripheral extension and by auto-inoculation especially on moist surfaces such as the scrotum, the labia and the flexures of the thighs. As the early lesions are painless, cases are seldom seen until ulceration is extensive or secondary infection is present. Extension is very slow occupying many years. The advancing edge is active, whilst previous ulcerations heal by scar tissue in which islands of active disease spring up from time to time. The partially healed areas become covered with thin depigmented skin

Destruction of soft parts is considerable on the penis the clitoris, the skin of the flexures and the anterior abdominal wall. Sometimes it implicates the urethra, vagina and anus, or it may burrow into the bladder

The lymph nodes are never involved, though lymph blockage may occur causing pseudo-elephantiasis. Strictures of the urethra produce vesico-vaginal fistulæ Usually a peculiarly offensive discharge exudes from the ulcerating surface Ulcerating granuloma is sometimes seen on the face or hands and rarely on other parts of the body

Treatment This consists in giving antibiotics during which rest in bed is desirable and the area should be dressed with eusol and sulphonamide powder Dihydrostreptomycin 2 g. daily for five days and thereafter 1 g. daily for ten days is most effective. Alternatively chlortetracycline 2 g. daily for ten to twelve days may be employed Either course may be repeated after two weeks, if clinical cure has not resulted Tartar emetic and other antimony compounds are now seldom used Surgical excision of early lesions is not required though in late cases with extensive ulceration and/or scarring surgical intervention may be required

Lymphogranuloma Venereum (*Inguinal Poradenitis Climatic Bubo*) A venereal disease of the tropics and subtropics it is common in India China Malaya Japan, Africa the Mediterranean the West Indies and South America The primary lesion occurs ten days to five weeks after coitus and consists of a small herpetiform ulcer on the prepuce which heals in a few days

and is seen in only a small proportion of males In females it has not been observed This is followed by subacute adenitis of the groin nodes sometimes accompanied by remittent pyrexia The inflammation may be either unilateral or bilateral Usually the virus spreads into the pelvis implicating the internal iliac and possibly the lumbar nodes as well Extragenital infections have been recorded on the tongue with implication of the cervical nodes, in the axilla and on the foot

The affected nodes slowly enlarge and then break down and suppurate at more than one point Usually the periglandular connective tissues inflame and the integuments become adherent till suppuration ceases Fistulous tracks then form from which a sticky serous fluid exudes These matted suppurating nodes of the groin form the prominent masses which are known as "climatic bubos" They are usually seen in males and are much more



FIG. 41 4 LYMPHOGRANULOMA VENEREUM SHOWING A LYMPHATIC FISTULA.

uncommon in women In light skinned persons a characteristic purple discoloration of the skin over the matted nodes is noticed Owing to the anatomical structure of the lymphatic vessels of the female genitalia the disease spreads to the vagina and produces some years later an elephantoid condition known as *esthiomene* or when it spreads to the rectum as the *genito-ano-rectal syndrome* In both sexes the subsequent scarring when the disease spreads to the bowel leads to rectal stricture, and may predispose to cancer

The virus has been isolated from inguinal bubos, and on intracerebral inoculation produces meningo-encephalitis in monkeys and mice. It can also be cultivated in the chorio-allantoic membrane of the chick. The virus particles can be stained and demonstrated in leucocytes and in the tissues by Giemsa or Castaneda's stains. Intraglandular injection of guinea pigs with the virus produces an inguinal bubo and is employed for diagnosis.

In man the intradermal test of Frei-Hoffmann is employed, the antigen being prepared from extracts of inflamed gland tissue or more recently from tissue culture. A positive result appears in twenty-four to forty-eight hours and consists of a local reaction with a central hard core which persists for a few days.

A blood test, the lymphogranuloma complement fixation test is now available in some centres and if positive to the titre of 1 in 20 with clinical signs of the disease, a definite diagnosis can be given.

Treatment The virus is susceptible to the sulphonamides in standard doses and to chloramphenicol and chlortetracycline. The response is best in the early stages before fistulous tracks have developed and rest in bed is desirable.

Sulphatriad or other sulphonamide, 4 g. daily for eight to twelve days combined with potassium iodide mixture is a satisfactory treatment Chloramphenicol or one of the tetracyclines 1 g. daily for ten to fourteen days is also recommended. Intravenous injections of T.A.B vaccine or even induced hyperpyrexia may be given if the bubos do not resolve Surgical excision is now rarely considered in the acute or subacute stage but in rectal strictures and esthiomene surgical measures are employed

Rectal strictures may be dilated weekly or monthly for long periods but if the sphincter is intact and surrounding fibrosis is not extreme excision with anosigmoid anastomosis is practicable. Elephantoid labia may be excised.

Filariasis and Dracontiasis

Filariasis is due to infestation with one of about eight distinct species of nematode worms. All are insect-borne

The most important is *Wuchereria (Filaria) bancrofti* The parent worms, long, white and thread like inhabit lymphatic vessels and nodes. The female varies from 60–100 mm in length by 0 25 mm in breadth The male is about half that size The female is viviparous and gives birth to large numbers of living embryos or microfilariæ (0·3 mm by 0·006 mm) which finding their way into the blood-stream, appear there in enormous numbers, swarming in the peripheral blood at night time maintaining so-called nocturnal periodicity These embryos are transmitted by various species of night-biting mosquitoes mainly *Culex pipiens C fatigans* and some species of Anopheles which act as intermediary hosts After undergoing developmental stages in the thoracic muscles, within a period of twelve to twenty days the larval filariæ are found in the proboscis of the mosquito ready for transference to a new human host where they develop into the adult form This cycle takes a considerable time, from six months to one year to accomplish. In the South Pacific Islands a local non-periodic variety is found in which the embryos appear in equal numbers in the blood-stream both by day and night. This Pacific form is transmitted by a distinct species of mosquito *Aëdes scutellaris*

W bancrofti is widespread in large areas in the tropics and subtropics from South Spain, North-west and Central Africa to India, South China Ceylon, Malaya, Arabia, North Australia, the Pacific Islands, the West Indies and South America, and as far North in the United States as South Carolina.

The embryo or microfilaria, is minute and worm like with a rounded anterior and tapering posterior extremity It is enclosed in a loose sac or sheath in which it can move freely yet is prevented from independent progression. On entering the mosquito host the sheath is shed permitting the now free embryo to move about in the stomach contents of the insect.

W malayi is a closely allied species found in Malaya, the Dutch East Indies Central India Ceylon S China and Indo-China The adults are identical in appearance with those of *W bancrofti* but the embryos which maintain a nocturnal periodicity differ in several features from those of *W bancrofti* It is transmitted by a different species of mosquito of the genus

Mansonioides The pathology of this form of filariasis appears to be the same as that of *W bancrofti*

Surgical lesions due to infestation with *W bancrofti* are numerous and common in highly endemic areas They may be due to the activity of the adult or dead worm or to the toxin produced by it alive or more especially dead or to the secondary bacterial infection In the mildest manifestation of disease it is often difficult to be certain of the filarial ætiology but diagnosis is made on the basis of endemicity of the disease and the discovery of microfilaria in the night blood samples In the more severe manifestations the etiology is not in doubt but in these the adult filaria are usually dead and microfilaria consequently absent

The pathology of all lesions is based on two factors an allergic response to filarial toxic products and a low grade inflammatory reaction around the sites of the adult worms

Lymphangitis. This is a common manifestation in the early stage There is usually a focal spot somewhere in the leg (which harbours a dead or dying adult worm) which is swollen red and painful often extending to an area 2-3 in (5-7 cm) diameter There is an ascending lymphangitis and nodes in the groin are swollen Pyrexia often reaches 103 F The condition usually responds to rest for two or three days Antibiotics are of doubtful benefit as there is no bacterial invasion but antihistamines may speed resolution

Funiculitis Epididymitis and Hydrocele The adult worms usually settle in and around the lymphatics of the groin and may be found in the spermatic cord. Here they cause swelling of both cord and epididymis and not infrequently an acute hydrocele containing opalescent or milky fluid in which can be found microfilaria In the more chronic stage the sac of the hydrocele becomes thickened and occasionally the contents purulent In most *cases the funiculitis will settle spontaneously but the epididymis remains* thickened hard and nodular and this has to be differentiated from *Esch coli* or tuberculous epididymitis. No treatment is indicated In the early stages of a filarial hydrocele, aspiration of the fluid may result in adhesion of the two layers of the sac and consequent cure but failing that the sac should be everted In the late stages, because cord and epididymis are usually involved, orchidectomy is usually preferable to excision of the sac.

Elephantiasis. This is the classical manifestation of filariasis and affects commonly the legs, scrotum and vulva while less frequently the arms and breasts. It never occurs unless the patient has been resident in a filarial area for many years and is the result of many succeeding and heavy infestations with the parasites. The legs and scrotum particularly may attain enormous size literally anchoring the patient to the ground, or on occasions serving the owner a market seller as a table on which to display his wares! The largest scrotum recorded weighed 224 lb (102 kg.) but few are now seen exceeding 20 lb (9 kg.) in weight. The skin of the elephantoid part is thickened and at first pits on pressure but this feature is rapidly lost as it becomes pigmented and verrucose. The subcutaneous tissue however remains œdematous. Minor trauma causes abrasions and infection and ulceration are not uncom mon in the legs. The preputial skin is often uninvolved and the penis be comes buried within a long tunnel of inverted thin prepuce

Treatment When the condition affects the scrotum vulva and breast, this is by amputation of the affected part Some reduction in size can be effected by bed rest, elevation and elastic bandaging of the affected part. Amputation

lymph nodes as well as in the skin which is their chief location. They invade the iris and cornea of the eye, producing keratitis punctata and eventually opaque pannus and total blindness. In some parts of W Africa, this is one of the common causes of blindness and the worm is known as the blinding filaria. The parent worms usually live in the centre of fibrous, subcutaneous tumours, which are most numerous on those parts in which peripheral lymphatics converge they are thus usually located in the axilla, in the popliteal space, in the intercostal spaces and in the suboccipital region. In the earlier stages they are often painful though later they become painless.

The tumours may be removed under procaine anæsthesia but unfortunately this procedure does not entirely eradicate the disease. Hetrazan is effective in this condition but is apt to produce serious allergic reactions.

Dracontiasis (*Guinea worm Disease*) The parasite is widespread in Africa Persia Turkestan, Arabia India and, to a lesser extent Brazil. In



FIG. 41 7 GUINEA WORM ON THE SOLE OF THE FOOT

addition to man it has been found in cattle, horses, dogs, wild cats jackals and leopards.

The female attains a considerable size, about 90 cm. by 1 5 mm. The male is smaller and has only rarely been found it is 2 1 – 2·9 cm. in length. The female contains enormous numbers of living embryos 650–750 μ. in length by 17 μ in breadth. They are extremely active and have rounded heads and a long, slender tail. The embryos are excreted through the prolapsed uterus, which is extruded by the head of the worm into water where they swim actively They develop in the body cavity of a crustacean (*Cyclops*), which is subsequently swallowed in water by a new host. The females reach maturity in about a year and in 80 per cent of cases migrate to the subcutaneous tissues of the leg, especially in the region of the ankle

or on the soles of the feet Any part of the body may be affected but in water-carriers the female worms appear in the centre of the back attracted there it is supposed by the presence of water in contact with the skin The female then projects her head through the tissues forming a vesicle which bursts on coming into contact with water and streams of embryos emerge Allergic urticarial or vasomotor symptoms appear at this time and may be thwarted by injections of adrenaline or antihistamines. Acute cellulitis often ending in necrosis is very common The most profound reactions and even multiple abscesses may be produced This is especially the case when the worms are lacerated or broken in attempts at extraction The end result may be arthritis with ankylosis of the joints, especially of the knee synovitis



FIG. 41 8. CALCIFIED REMAINS OF DEAD GUINEA WORMS IN THE THIGH, CAUSING SCIATICA.

epididymitis and tendinous contractions Late sequelæ are caused by calcified remains of dead parasites which may be demonstrated by X rays. Sometimes sciatica is thus produced

Treatment Removal of the dead worm may be effected by the time-honoured method of gradual and daily winding on a stick Better still the worm may be killed by injecting with bichloride of mercury 1 100 recently also a method of injection around the worm of 1 g. of phenothiazine in solution has been advocated The worm may then be extracted by surgical excision or intermittent traction assisted by massage Loops of the worm as they appear through skin incisions are hooked out by means of a strabismus hook.

Leprosy, Syphilis and Yaws

Leprosy *This disease is widely distributed throughout the tropics yet,* except in its advanced stages, the clinical features of the disease are not well recognized and early cases may easily be missed.

It occurs in two main types, (a) *lepromatous* and (b) *tuberculoid* but there is a large group which falls between the two well defined types This *intermediate* group of cases, left untreated or treated inadequately tend to progress to the lepromatous type and rarely the other way It is usually said that the lepromatous variety develops in patients with low resistance or invaded by a virulent strain, while the tuberculoid develops in those individuals with relatively high resistance.

The disease is further subdivided into its clinical manifestations as follows —

Lepromatous macular infiltrative, nodular neural (secondary).
Indeterminate macular neuromacular
Tuberculoid neural macular papular plaques, reactive.

It is of importance surgically partially because of its protean characteristics which may masquerade as a variety of other skin lesions, and partly because in the neural varieties deformities may result from paralysis of muscle and ulceration may follow multiple trauma to an anaesthetic part When the disease has become quiescent as a result of treatment tendon transplantation is of considerable value especially in restoring extension of the interphalangeal



FIG. 41 9 A CASE OF LEPROSY

joints which has been lost as a result of ulnar nerve paralysis. *Ulceration is* frequently associated with a low grade osteomyelitis and may need curettage and removal of sequestra and possibly skin grafting to ensure healing. In *the deformed foot amputation may be the most satisfactory method of re*storing satisfactory function and in many areas the Syme s amputation still has a place in surgical treatment In the lepromatous variety elephantiasis of legs and feet is not uncommon In this type also lesions in the eye and *optic nerve are common and blindness results.*

Treatment The modern treatment with sulphones has completely displaced former remedies and in the early stages is capable of producing arrest of the disease in most patients. In the late stages results are less *satisfactory* The disease however is not a lethal one and death occurs as a result of renal complications, nephritis and amyloidosis, tuberculosis or sepsis.

Syphilis. Syphilis is world-wide and exceedingly common except in the most remote and isolated peoples. One of the main reasons for its

almost universal distribution lies in the attitude of the patient who regards it as of little importance owing to the well known fact that early primary and secondary stages produce little pain

Although there is acquired immunity from previous yaws infection and these two diseases so closely allied appear so mutually protective that it still remains a debatable point which particular lesions are attributable to which, yet it is undoubtedly true that Old World syphilis does not occur in Pacific Islanders Nevertheless when syphilis is introduced to a new area it spreads with that rapidity and virulence which characterized this disease in the fifteenth century in Europe Thus in the early days of the present century it spread to Uganda and caused untold destruction

The yaws syphilis question is complicated by the fact that intermediate forms between the two classical forms of these diseases have become evolved as in the non venereal child syphilis of Arab tribes where it is known as "Bejel" This form is spread by contact is of low virulence gives a positive Wassermann reaction and corresponds to the endemic syphilis of Asia Minor

Primary Syphilis Sore (Chancre) This may pass unnoticed because of the high incidence of soft sores balanitis and phagedænic sores which are painful, appear earlier and therefore attract attention Extragenital chancre is relatively more frequent in the tropics than in temperate zones The Hunterian chancre may become phagedænic in men with a long tight prepuce The diagnosis of primary syphilis in women is made difficult because the lesion is often concealed and women show both ignorance and diffidence in seeking medical aid Ideally diagnosis is made by finding the *Treponema pallidum* in serum expressed from a sore but in practice reliance is generally placed on serological tests Wassermann Kahn or V D R L reactions. Before using these tests however as the sole guide to diagnosis it is necessary to know the prevalence of other diseases in the area, yaws, malaria, etc and allowance must be made for positive results caused by those diseases.

Secondary Manifestations These may be so slight that they are often missed and rashes are difficult to see in highly pigmented skins, especially when associated with prickly heat and fungous eruptions on the skin Roseolar papular and papulosquamous lesions occur more commonly than in Europe Anal condylomata are frequently found in negroes. Syphilitic fever anæmia and an arthritis of the rheumatoid type now seldom seen in Europe are other features Syphilitic iritis is commoner in negroes

With urbanization and development of laboratory facilities latent syphilis will be increasingly diagnosed by the widespread application of a blood test for syphilis e g in antenatal clinics and routinely in a blood transfusion service.

Treatment with penicillin at this stage especially within four years of the primary infection is of very great value in preventing tertiary syphilis

Tertiary Syphilis This may occasionally produce the most destructive lesions Extensive facial lesions, including destruction of the nasal cartilages and ulceration of the nasopharynx occur Osteoperiostitis simulating neoplasm occurs particularly in bones subject to external trauma Optic atrophy is common in the West Indies, East Africa and South China

Neurosyphilis may be detected by the routine examination of cerebrospinal fluid in latent and tertiary syphilis at a stage before the development

of general paresis or tabes. There is still little prospect of relief for the unfortunate patient with Charcot s joints, tabetic bladder dysfunction or impotence

A great predisposition to the development of aortitis aortic incompetence and aneurism is found where males are required to undertake work involving strenuous physical exercise, e g dockyard coolie, miner etc. Operative treatment has in the past seldom been available, but there now appears opportunity for thoracic surgery especially for the early cases, which can only be detected by routine X rays and cardiography

Congenital Syphilis This is a preventable disease and will become a rarity in due course with the development of antenatal blood testing. The baby with bullous eruptions around mouth, anus and on the palms and soles responds very quickly to penicillin injections. Babies with pseudo-paralysis of a limb due to epiphysitis can be diagnosed by X ray and this lesion also responds quickly to penicillin.

Congenital syphilis in the older child and adult manifests itself by the development of interstitial keratitis Hutchinsonian incisor teeth, depressed and widened nasal bridge Eighth nerve deafness is not common.

The current treatment of syphilis employs penicillin only either as procaine penicillin in oil with aluminium monostearate (P.A.M) or benzathine penicillin The generally accepted course is one of six million units given in ten to fifteen days for all stages of the disease except neurosyphilis and vascular syphilis, where twelve to twenty million units are recommended Preparatory treatment with bismuth for two weeks is now seldom required

For any infectious cases at least 1,200 000 units should be given at the outset (epidemiological dose) In the last month of pregnancy two depot injections each of 4 ml. P A M may be given simultaneously into the buttocks of patients who live in the wilds.

Yaws (*Frambesia*) This is an almost universal affection of the tropics. It is very closely allied to syphilis or may possibly constitute a primitive form of this disease Yaws is common in tropical Africa, the West Indies, South America, Ceylon, the Pacific Islands, Papua, Melanesia, the East Indies and Malaya. In India and China it is comparatively rare. During recent years this disease has spread rapidly in Kenya, Tanganyika and Uganda but on the other hand it has greatly decreased in Guiana Ceylon and Barbados, where it was formerly common.

The causative organism is *Treponema pertenue* which is morphologically identical with *Tr pallidum* of syphilis Yaws is highly contagious, and circumstances which produce close contact favour its spread some breach of surface is necesary The infectivity of the secretions from yaws lesions was well known to slaves in the West Indies who practised auto-inoculation on their children, thus producing immunity The Wassermann and Kahn reactions are positive in yaws, as in syphilis.

The infection is spread by direct contact, and the incidence of the disease in house or family contacts is always great. There is no evidence of congenital transmission. Manifestations of the disease are commoner in children. Where syphilis and yaws occur together as in the Phillipines and West Indies yaws is common in the country districts and syphilis in the towns.

Primary Lesion The " mother yaw " as it is called appears after an incubation period of three to four weeks as a papule or granuloma In

young children who are habitually naked the mother yaw may be on the genitals, but the common sites are on the limbs breast lip or face

In different countries the primary yaw may show a predilection for certain sites depending on the customs of the people It is not painful unless traumatized As in syphilis, the regional lymph nodes are enlarged and constitutional upset fever and joint pains are common

Secondary Lesion The eruption of the secondary stage occurs two to four months after the primary lesion This may show marked pleomorphism and different stages of evolution may be present at one time The eruption



FIG. 41 10. SECONDARY RASH OF YAWS—ACUMINATE TYPE.

may be roseolar macular or popular with variation in size and grouping. Papular lesions are often found at the angles of the mouth, in the axillæ anal cleft and inguinal region.

The typical yaw is a papule of considerable size The lesion gradually grows into a rounded excrescence, the yellow material forming a complete cap encrusting the papule When the crust is removed the swelling is red and oozes pale yellow serum which resembles honey and when inspissated, forms a fresh cap to the yaw The yaw attains its maximum development in two weeks and for several more it remains stationary when it begins to shrink The crust then falls off leaving a highly pigmented spot, though sometimes depigmentation may occur

On the limbs the primary yaw is often surrounded by a crop of secondary lesions, mother and daughter yaws. On the sole a large yaw may ulcerate and render walking difficult. In other cases a fissured hyperkeratosis is found both on the soles and palms

Treponema pertenue may be found in the serum from the lesions as well as from the lymph from the affected nodes and the blood tests are positive.

Tertiary Stage It sometimes happens that a secondary yaw instead of being absorbed, breaks down to form an ulcerating gumma though as a rule

tertiary lesions are seldom observed in cases which present late secondary manifestations. Deep ulcers are frequent, involving the lower part of the leg. Other tertiary lesions express themselves in keratoderma of the palms of the hands, in dactylitis, swelling of the phalanges, onychia, paronychia and atrophy of the nails. Circumscribed periosteal nodes occur on the anterior aspect of the long bones, as well as osteitis of the metatarsal and metacarpal bones. In the tibia this results in the sabre-shaped deformity or "boomerang leg," so often described in Australian aborigines, similar to that sometimes observed in tertiary syphilis.

Chronic periostitis of the clavicle is common in the Pacific Islanders. Juxta-articular nodules, fibrotic tumours situated over the olecranon, lower end of the femur and along the course of the long bones, are characteristic of yaws, though a somewhat similar condition has been described, though rarely, in syphilis. Originating subcutaneously, these nodules may reach the size of an orange. They rarely ulcerate or suppurate.

Gangosa. Destructive rhinopharyngitis commences as an ulcer of the soft palate. It usually destroys the hard palate, the soft parts, cartilages and



FIG. 41 11. GANGOSA IN AN AUSTRALIAN ABORIGINAL

nasal bones, sparing the upper lip and giving off a most offensive odour. As a rule the larynx is spared.

Goundou. Goundou or anakhre is a bony outgrowth of the nasal bon especially found in West Africa and has given rise to the legend of t horned men of Africa." Commencing in childhood these paranas swellings may acquire a great size and eventually obstruct vision. In sever cases there is also hyperostosis of the anterior part of the maxilla. Durin their growth they are associated with persistent headaches and a purulen discharge from the nose. Treatment consists of incising, displacing the periosteum and chipping away the bony outgrowth with a chisel.

The treatment of yaws in all stages is by penicillin, possibly supplemented

by iodides in the late tertiary stages Surgical treatment is necessary for chronic ulcers, deformities and the removal of bony outgrowths nodules etc. In the places where infectious yaws occurs medical treatment is generally available infrequently and it is therefore imperative to use one of the long-acting penicillins, P.A M or benzathine penicillin or Benapen giving a dose of 1,200 000 units intramuscularly once weekly or as circumstances permit, for 4 doses. Chlortetracycline and oxytetracycline are effective but their cost, and the necessity for supervision of dosage makes them suitable only for hospital use.

Specific Ulcers

Tropical Ulcer Much has been written about this condition and the only thing which seems certain in its ætiology is that it is not due to a specific infection It is seen characteristically in hot humid climates and especially among labourers working constantly on flooded land It is an extremely common cause of disability among labour forces The surface of the ulcers abounds with organisms of all varieties and it is almost certain that these are secondary invaders. The condition is probably simply a traumatic ulcer which refuses to heal, and may on occasions spread rapidly due to the debilitated state of the patient and the macerated skin of the legs as a result of constant exposure to water

Treatment is difficult and unless the general nutritional state is improved and working conditions changed the ulcer is low to heal and readily recurs. Antibiotics, curettage, excision and skin grafting all have their place Rapid healing of tropical ulcers however was seen among prisoners of war in the Far East as soon as they were liberated and placed on a good diet



FIG. 41 12. VELD SORE.

Veld Sore (*Desert Sore Cutaneous Diphtheria*) This is seen more frequently in dry climates than in the humid ones which favour tropical ulcer It occurs on exposed parts, mainly those covered by hairs, such as the dorsum of the hands, forearm, elbows and knee joints and sometimes also on the face, on the eyebrows and cheeks A vesicle first forms, usually in the vicinity of a hair follicle On bursting it exposes a shallow ulcer

covered with a thin grey pellicle. The raw ulcerated surface is extremely tender The ulcers then become chronic, punched out and circular and in this stage are most intractable to treatment.

The diphtheria bacillus (*Corynebacterium diphtheriæ*) can usually be isolated from the serous exudate in the early stage, but later the sores become secondarily infected with pyogenic organisms. Diphtheritic polyneuritis with paralysis of arms and legs has been recorded.

Treatment by injection of antidiphtheritic serum is effective in the early stages. Chronic sores heal best with sulphonamide powders or pastes. Attention must be paid to diet and general hygiene.

Leishmaniasis. A *widespread infection this is seen in various distinct* manifestations including the generalized visceral infection Kala-azar dermal leishmanoid, oriental sore, espundia or nasopharyngeal leishmaniasis.



FIG. 41 13 DIFFUSE PAPULAR DERMAL LEISHMANIASIS.

The causative organism is the Leishman Donovan body an oval or rounded object 2–4 μ in diameter containing an oval trophonucleus and a *smaller rod-shaped rhizoplast. They are found often in large numbers,* mainly within endothelial cells, histiocytes and monocytes in the blood-stream. All the various forms of leishmaniasis are insect-borne diseases transmitted by various species of sandfly (*Phlebotomus*)

The parasite is readily cultivated outside the body at 22°C and then assumes a flagellated, or *Herpetomonas* form which normally develops within the body-cavity of the sandfly Dogs, cats, monkeys and mice can *be infected, but the most susceptible animal is the hamster*

The generalized infection, or kala-azar assumes the aspect of a tropical fever (India, Mediterranean, Central China, Central Africa and Brazil) with hepatomegaly and splenomegaly It produces an irregular fever accompanied by anæmia and leucopenia which may proceed to agranulocytosis. The parasite is *Leishmania donovani* In the Mediterranean area the disease is mainly seen in small children (*L. infantum*) and is associated with a similar infection in dogs (*L. caninum*).

The treatment consists of intravenous injections of antimony (sodium antimony gluconate or Neostibosan) diamidinostilbene (stilbamide) or *pentamidine.*

Dermal Leishmanoid A generalized cutaneous form of leishmaniasis occurs as subcutaneous nodules with depigmentation (which may be mistaken for leprosy) widely distributed over the body It is interesting that the majority of these cases are those who have been previously cured of kala azar by antimony treatment.

Oriental Sore This variety is found in the Mediterranean North Africa the Middle East India South China, Queensland and South America in association with espundia The sores are single or multiple appearing on the exposed parts, especially the face, arms and legs They may occur on the



FIG. 41 14 ORIENTAL SORE ON THE NOSE.

cheeks, eyebrows, nose, lips or ears. Very often they are accompanied by an allergic dermatitis, which is more intractable. The sores, too may extend by lymphatic spread and produce nodules in the lymph vessels

At first papular they soon break down into ulcers capped by a limpet like scab exuding a scanty ichorous discharge, or they may be covered with fine papery scales. Subsidiary sores may form round the parent ulcer Secondary infections with pyogenic organisms are common and affect the appearance of these sores. Multiple infections are not uncommon and over a hundred sores have been often recorded. In the earlier stages the parasites, *L. tropica* may be found in large numbers at the extending margins of the sore, occurring in bundles or rosettes often enclosed in histiocytes or leucocytes. When secondarily infected with pyogenic cocci the parasites are found sparingly in the deeper layers of the sore. They are indistinguishable from *L. donovani*

Various forms of treatment are recommended. Single isolated sores respond to intravenous injections of antimony (Neostibosan or sodium antimony gluconate), sometimes also to intramuscular injections of stibophen or fouadin (0·5 to 5 ml.) When the sores are septic they must be scraped, cleansed with eusol dressings and the application of sulphonamide paste. Indolent sores on the nose or on the ears require surgical treatment by paring or scraping. Individual sores can also be effectively treated by carbon dioxide snow or ionization. A diffuse, or verrucose form, affecting the hands and legs sometimes occurs. It is much more chronic in character and must be treated by surgical excision and skin grafting.

Espundia A much more serious and destructive form of leishmaniasis (*L. braziliensis*) attacks the mucous membranes of the mouth and nose. This nasopharyngeal leishmaniasis is mainly found in South America, although a

similar condition has been seen in the South Sudan. It is also commonly associated with cutaneous leishmaniasis.

The initial sore is of the chancrous form of the ordinary oriental sore type, then after an interval of months or even years, eroding and fungating ulcers break out on the tongue or in the mouth and nasal cavities, destroying or obstructing them, thereby causing the most terrible deformities, till the patient dies of exhaustion or of terminal bronchopneumonia. The adjoining lymph nodes are often involved When the pinna is affected it is known as gum-picker s ear (oreja de chicleros) Leishman bodies are found sparingly in the sores.

Antimony treatment is effective in the early stages, but when severe destruction of the palate and pharyngeal mucosa has taken place this specific treatment appears to be of little avail.

Fungus Infections

Fungus infections of the skin are extremely common in all tropical countries but especially in hot and humid areas. *Epidermophytosis* (athlete s foot) acquires a local name in almost every country where it is seen but it is everywhere the same disease.

Mycetoma. (*Madura Foot Pseudo-actinomycosis*) This condition produces tumefaction and liquefaction of tissue The foot becomes infected



FIG. 41 15 MYCETOMA OR MADURA FOOT

by direct inoculation with the fungus (*Discomyces madurae* and allied species). Nodules form and break down into sinuses which discharge thin, oily purulent material containing variously coloured granules. The lesion gradually spreads with bone destruction and atrophy of the leg proximally

due to disuse. Occasionally the lesion may be seen in the hand. Radiologically there will be seen a soft tissue mass with extensive bone destruction. Sequestra are never found. Unless the diagnosis is remembered the lesion may be confused with a malignant neoplasm of bone or soft tissue but the sinuses and the thin discharge are characteristic.

Treatment is unsatisfactory. Large doses of antibiotics may arrest the condition but will not restore the bony skeleton and amputation is usually necessary.

Many other fungus infections occur more infrequently such as Blastomycosis producing fungating skin lesions, *Chromoblastomycosis* producing "mossy foot" *Sporotrichosis* producing cutaneous lesions resembling gummata, *Rhinosporidiosis* producing nasal and sometimes oral and conjunctival polypi.

Poisonous Bites and Stings

Snake-bite. Great damage is caused by snake bites in most tropical countries. Surgical complications occur mostly after viperine bites especially by Russell's viper (*Vipera russelli*) in India. The bite causes severe pain with rapidly extending œdema. Collapse, thready pulse, nausea, vomiting, dilated pupils with coma soon supervene. Should the effects of the intoxication wear off the local condition of the wound becomes aggravated with extensive sloughing, malignant œdema and sometimes tetanus and hæmorrhage from mucous surfaces.

Treatment should be immediate to be effective. *To localize the toxin*, a ligature should be applied immediately above the bite. Amputation also above the bite should be carried out at once. If this cannot be performed multiple incisions, combined with local venesection, can draw off a great deal of the poison. An injection of specific antiserum if available should be made intravenously as soon after the bite as possible.

Scorpion Stings. These produce a considerable degree of disability and may be fatal in small children. They are usually extremely painful. In addition to focal symptoms, muscular cramps, profuse perspiration, pyrexia, vomiting and convulsions may be produced.

In treatment, the site of the sting should be incised and thoroughly washed out with a strong solution of potassium permanganate. Pain is relieved by the application of liquor ammoniæ fortis and generalized symptoms by injections of adrenaline.

Spider Bites. The bites of certain species of widow-spider in America (*Latrodectus mactans*) and in North Africa and the Near East (*L. lugubris*), produce inflammation and œdema at the site of the bite and sometimes a generalized urticaria. Sloughing of the skin may occur. The toxin stimulates the myoneural junctions producing nerve pain. Rigidity of the muscles especially those of the abdominal wall supervenes which become board-like simulating an acute abdomen or appendicitis, for which condition it may be frequently mistaken. Intravenous injections of calcium gluconate (10 ml of a 10 per cent. solution) relieve the pain and decrease the muscular spasm.

Subcutaneous Myiasis. This is produced by the larvæ of certain flesh flies in the skin. The eggs are deposited on the skin and clothes, and, when hatched, the larvæ penetrate the skin and produce inflammatory nodules, mostly on the back and arms. From the aperture of these a seropurulent

fluid containing black fæces emerges. These nodules resemble suppurating sebaceous cysts. In South America the species is the "Macaw worm" (*Dermatobia cyaniventris*) and in tropical Africa the "tumbu fly" (*Cordylobia anthropophaga*). When removing the larva the aperture of exit is widely stretched with forceps, and the larva then slips out.

Section Six

THE SURGERY OF THE ALIMENTARY TRACT

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Chapter 42

THE ŒSOPHAGUS

Introduction

Anatomical Considerations. The œsophagus reaches from the lower extremity of the pharynx to the cardiac orifice of the stomach, a distance of about 25 cm., or 10 inches. It commences at the level of the crico-pharyngeal sphincter the muscle fibres of which arise from the cricoid cartilage, while its lower limit is approximately the lower end of the sternum The distance from the upper central incisor teeth to the diaphragm is about 16 inches, or 40 cm The tube is not quite in the middle line but deviates to the left as it passes through the posterior mediastinum The pericardium is in relationship with the œsophagus in front, the aorta with its left wall and the pleura on each side Its narrowest portions are its upper end which is kept closed by the cricopharyngeus muscle in the centre at about 23 cm. from the upper teeth, where the aorta presses against its left lateral wall at about 25 to 27 cm., where the left bronchus crosses it and at the diaphragmatic hiatus. The two vagus nerves are also in immediate relationship with it.

Methods of Examination. There are four of these

(1) *Palpation* may reveal broadening at the level of the larynx, due to infiltration with growth or secondary nodes in the supraclavicular fossa. Surgical emphysema or para-œsophageal abscess may be detected in cases of perforation.

(2) Examination with a *laryngeal mirror* may reveal the upper border of a neoplasm or may show the presence of froth in the pyriform fossa due to œsophageal obstruction lower down, or paralysis of a vocal cord caused by involvement of the recurrent laryngeal nerve in a carcinomatous growth.

(3) *Radiography* is of assistance in the examination of the œsophagus. Metallic foreign bodies can be seen and accurately located and by the use of swallowed barium it is possible to determine the situation of a stricture, and the amount of dilatation of the œsophagus above it.

(4) The use of the *œsophagoscope* has advanced the surgery of this organ If local analgesia with cocaine is used it is advisable to administer a preliminary injection of Omnopon and scopolamine to dull the patient's sensitiveness, and also to check the salivary secretion. General anæsthesia may be employed and is to be preferred in most cases. With the patient lying on his back, it is possible to introduce the instrument and gently to *insinuate it down the œsophagus* By this means foreign bodies, growths, strictures, etc. can be seen, and direct treatment, controlled by vision, can then be adopted. The blind use of rigid bougies is to be avoided, except in rare circumstances

As most cases of œsophageal disease are associated with difficulty in swallowing, it is appropriate to make some general observations on the subject of dysphagia.

Dysphagia. By this is meant a condition in which swallowing is painful or difficult The causes are very numerous, and may be arranged as follows

Buccal and Pharyngeal Acute or chronic inflammation, whether simple scarlatinal, diphtheritic, etc. ulceration of syphilitic or malignant origin stenosis as a result of ulceration paralysis, *e.g* labioglossolaryngeal or bulbar spasm impaction of foreign bodies retropharyngeal abscess tumour

Laryngeal Acute or chronic laryngitis tuberculous, syphilitic or malignant disease.

Œsophageal Congenital malformations, acute or chronic inflammation, impaction of foreign bodies, the presence of diverticula, œsophagectasia, and simple or malignant stricture.

Extrinsic (*a*) In the *neck* goitre enlarged nodes of malignant or simple type, aneurysms, tumours growing from the vertebral bodies. (*b*) In the *thorax* mediastinal growths or lymph nodes, aneurysms of the aorta and large vessels.

To investigate a case of dysphagia, the following information should be obtained (*a*) The method of onset, whether acute or chronic—if the former it is probably due to a foreign body (*b*) the condition of the pharynx as seen from the mouth (*c*) the condition of the neck as seen and felt from without, whether or not a tumour is to be felt behind the cricoid, or whether a goitre or aneurysm exists (*d*) the character of the voice as indicative or not of laryngeal disease a laryngoscopic examination should be made (*e*) the chest must be examined clinically and radiologically (*f*) the œsophagus is examined by X rays and the œsophagoscope. If the obstruction is in the œsophagus the patient s age and general condition will give *prima facie* evidence as to whether or not it is due to malignant disease but it must not be forgotten that the stenosis *per se* causes loss of flesh and weight.

Affections of the Œsophagus

Malformations of the Œsophagus. These may be congenital or acquired.

Congenital Malformations Various forms of atresia may occur and most of these are apparent at birth Œsophageal stenosis or stricture may also exist. These conditions are described in the chapter devoted to pædiatric surgery

Congenital short œsophagus is a condition which usually does not give rise to symptoms until adult life Since these symptoms are all gastric and since the condition has to be distinguished from hiatus hernia it is described in Chapter 45

Acquired Malformations These are mostly diverticula Two types have been described (*a*) *Pressure diverticula* may be found near the mouth of the œsophagus and occasionally at the lower end. Those causing symptoms at the upper end are described in the preceding chapter (*b*) *Traction diverticula* are rare they occur on the anterior wall near the bifurcation of the trachea, and are due to cicatricial traction from without by adhesion of an inflamed (often tuberculous) bronchial node to both œsophagus and trachea They are always of small size and cause no symptoms. They are seldom recognized *ante mortem*, except, perhaps, by direct œsophagoscopy

Foreign Bodies. These often lodge in th œsophagus, especially in children. The usual site of impaction is at the cricopharyngeal fold or at the level of the thoracic inlet. Portions of food coins bones pins, dentures, etc., are the objects usually met with. The patient complains of pain while

swallowing is painful or impossible Large bodies may be impacted against the aperture of the larynx and may cause sudden death from dyspnœa if the obstruction is not so great and remains unrelieved œdema of the glottis may supervene. Impaction of sharp objects may be followed by ulceration perforation and death either from hæmorrhage, owing to one of the large vessels being opened as a result of parapharyngeal suppuration or from suppurative mediastinitis. The presence and situation of an opaque body is best diagnosed by radiography

Treatment This necessitates the use of the œsophageal speculum or œsophagoscope. Removal should never be attempted blindly by forceps or a coin-catcher as in earlier days and such patients are now usually treated by a laryngologist Secretions are removed by suction until a clear view is obtained. The foreign body is then grasped with suitable forceps and, *after careful disimpaction of any embedded points, it is removed* together with the speculum.

If perforation has taken place, a parapharyngeal or para-œsophageal abscess may form It is permissible to treat the patient expectantly with antibiotics but if localization occurs an incision should be made along the anterior margin of the left sternomastoid muscle because the œsophagus naturally curves in that direction. The surgeon carefully finds his way between the carotid sheath on the outer side and the larynx and trachea on the inner avoiding or dividing the thyroid vessels. The external wound is kept open with gauze soaked in flavine and left to be closed at a later date.

If a foreign body passes the upper narrow parts of the œsophagus, it will almost invariably slip through into the stomach, and will pass along the intestinal tract in most cases without causing trouble. In rare cases perforation occurs in the thoracic portion of the œsophagus, with resulting para-œsophageal abscess or mediastinitis Drainage should be established into the œsophagus, an incision being made under direct vision through an œsophagoscope thoracotomy may be required and can sometimes be carried out by the cervical route.

Rupture of the Œsophagus. This may occur during instrumentation, but *it can also occur spontaneously sometimes in the site of a peptic ulcer* but occasionally for no obvious reason. When this happens the patient is profoundly shocked and there are signs of a hydrothorax which may be confirmed by radiography Treatment by thoracotomy must be immediate if death is to be averted. The pleural cavity is drained and the rent in the œsophagus repaired Naturally the mortality is high.

Hypopharyngitis. A condition of simple inflammation of the mucosa of the mouth of the œsophagus may occur and this is part of the syndrome described by Paterson and Brown-Kelly if associated with anæmia and glossitis.

Paterson-Brown-Kelly (*Plummer Vinson*) Syndrome. In this condition the inflammation extends into and causes spasm of the cricopharyngeus muscle. It occurs in middle-aged women and may be the precursor of malignant disease in this situation. Often there is chronic superficial glossitis, microcytic anæmia, brittle finger nails and achlorhydria. The treatment consists in dilatation of the cricopharyngeal sphincter together with the administration of large doses of liver extract, iron and nicotinic acid.

Spasm of the Œsophagus. Lack of relaxation of the cricopharyngeal sphincter and sometimes actual spasm of the muscle give rise to dysphagia

referred to the level of the cricoid cartilage and to a feeling of something being stuck in the throat. There is usually some reflex cause

The condition may be purely neurotic, and is then associated with the sensation of a lump which moves this is known as *globus hystericus*

Treatment in cases of reflex type must be directed to the cause, while functional cases require general medical treatment and possibly dilatation of the cricopharyngeal sphincter under direct vision.

Simple Stricture of the Œsophagus. This is located near its commencement, just behind the cricoid cartilage, or more often at the level of the left bronchus, and is most frequently the result of swallowing corrosives with cicatrization of the subsequent ulceration In most cases more than one constriction is present. At the cardiac orifice a stricture may arise from the healing and contraction of a peptic ulcer The main symptom is gradually increasing difficulty in swallowing solids and later fluids. If the obstruction

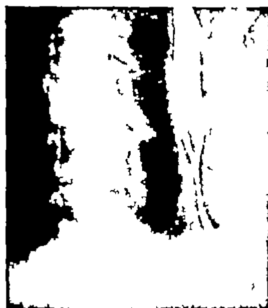


FIG. 42 1 SIMPLE STRICTURE OF THE ŒSOPHAGUS CAUSED BY SWALLOWING A CORROSIVE.



FIG 42.2. ŒSOPHAGITIS ASSOCIATED WITH A SHORT ŒSOPHAGUS.

is high, food is returned immediately but if lower down, the œsophagus may become moderately dilated and the food collects for a time and then returns unchanged There is no pain in this form of stricture, although the patient is usually able to indicate the level of the obstruction As the stricture narrows, he becomes steadily emaciated from sheer starvation and may even die Radiographic examination after the swallowing of barium, enables the outline of the stricture to be seen. The smoothness of the walls and the tapering appearance, together with the history allow a correct diagnosis to be made in almost all cases.

Treatment (*a*) Dilatation of the stricture may be carried out by means of graduated bougies or a dilatable bag under direct vision through an œsophagoscope An interval of some days should elapse between the attempts at dilatation (*b*) Dilatation by perforated bougies attached to a whalebone

staff and guided through the stricture along a previously swallowed thread according to the method of Plummer is efficient in some cases. (*c*) Gastrostomy is necessary in severe cases with emaciation A swallowed thread may subsequently be drawn out through the gastrostomy opening, and an endless thread created by uniting the two ends. A flexible bougie is attached to the lower end of this thread, and is drawn up through the strictures (retrograde dilatation Tucker's method) Graduated metallic olivary bougies

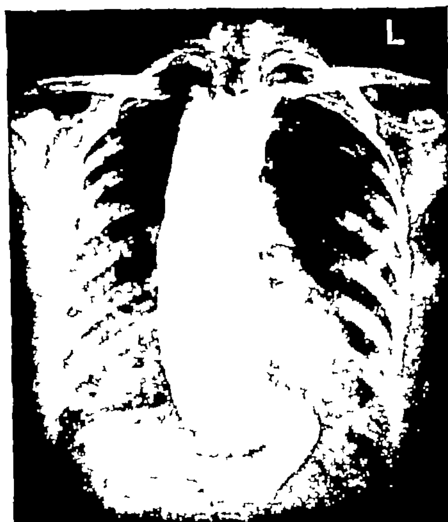


FIG. 42 3 ŒSOPHAGECTASIA.
Note the smooth, conical outline of the constriction, and also the dilatation and tortuosity of the œsophagus above it.

may alternatively be used. At each treatment the smaller sizes are followed by bigger bougies, until sufficient dilatation has been attained. A tapered bobbin may be inserted from the mouth and drawn through the stricture into the stomach by the constant pull of an elastic band. (*d*) Excision of the stricture with anastomosis or œsophago-gastrostomy may sometimes be required.

Œsophageal Varix. Dilated veins around the lower end of the œsophagus occur with portal hypertension This is one of the sites of anastomosis

between the portal and systemic systems Reference should be made to Chapter 47 where this is described.

Œsophagitis. There are two varieties which are quite distinct clinically

Mechanical This may or may not be accompanied by ulceration and is the result of the swallowing of corrosives or irritants or in a more localized form by the impaction of foreign bodies. Pain and dysphagia are the symptoms and if the condition is sufficiently severe intravenous fluids and even gastrostomy may be needed

Peptic or Reflux Incompetence of the cardiac sphincter allows the acid pepsin to be regurgitated into the lower œsophagus with at first, mucosal inflammation and later superficial ulceration. Symptoms are pain behind the lower end of the sternum and heart burn. Skiagrams often reveal that there is either a hiatus hernia or a short œsophagus, but the condition may also occur in association with peptic ulceration or cholecystitis. Treatment may be medical by diet, alkalies and sleeping on raised pillows. But if the condition progresses operation is called for A hiatus hernia is reduced and the stomach sutured below the diaphragm if ulceration is extensive the lower part of the œsophagus may require excision, though this allows reflux and may reproduce the condition. The best approach is through a thoracic incision.

Œsophagectasia (*Cardiospasm, Achalasia of the Cardia*) These terms apply to a condition in which there is a hold up of food in the lower œso-



FIG. 4 4 SKIAGRAPHIC APPEARANCES OF 1 CARDIOSPASM. 2 "SHORT" ŒSOPHAGUS. 3 CARCINOMA OF THE LOWER END OF THE ŒSOPHAGUS.

phagus above the diaphragm until a sufficient weight has collected to carry it through the cardia. The causation remains unknown but is probably due to physical factors and also to neuromuscular imbalance There is no true spasm in the early stages but œsophagitis may later lead to secondary spasm. There is also no muscular hypertrophy of the affected segment though there is in the dilated œsophagus at a higher level. Degeneration of the ganglia of Auerbach s plexus occurs and this is replaced by fibrosis. Radiographic studies suggest that even in the early stages of the disease there is disordered muscular activity affecting a large part of the œsophagus and not just the cardiac region Psychogenic factors certainly play a large part in this condition. An alternative explanation of the disease is gradual dilatation of

the viscus by the swallowing of air extending over many years and even starting in childhood Once the œsophagus is permanently dilated peristalsis is no longer effective even if the muscle is hypertrophied It is noticeable that dilatation is present well above the level reached by food and saliva

Symptoms The disease becomes evident most often in middle aged women and is usually of very gradual onset. There may be occasional difficulty in completing the act of deglutition and possibly choking attacks during meals more often patients complain of a sensation of weight and discomfort in the lower part of the chest There is sometimes regurgitation of decomposed food material in large quantities The œsophagus is markedly dilated as revealed by radiography Examination with the œsophagoscope confirms the diagnosis

Treatment Only two methods of treatment have stood the test of time, and both aim at the rupture of the circular muscle fibres of the cardia Dilatation may be endoscopic using a bag which is distended with water This treatment may need repetition at long intervals Operation may take the form of a thoracotomy or laparotomy according to the views of the surgeon concerned but in either case a longitudinal incision of at least 7 cm. is made down to the mucosa of the œsophagus and this is carried well down on to the anterior wall of the fundus of the stomach. This is Heller s operation and it gives much better results than any of the methods of œsophago-gastrostomy which though satisfactory at first, tend to be followed by œsophagitis.

Simple Tumours. These are rare Leiomyoma has been described and may be pedunculated or intramural The former have been known to be regurgitated through the mouth The latter can be removed by the transthoracic route Even benign tumours may produce symptoms of sufficient severity to cause death by obstruction, hæmorrhage or perforation.

Carcinoma. Cancer of the œsophagus is a lethal disease killing approximately 1,300 men and 850 women each year in England and Wales. These figures include the post-cricoid growths which are more common in women, so that it should be stressed that as far as carcinoma of the intrathoracic œsophagus is concerned the disease is about five times more frequent in men than in women. The average age at onset is over sixty but the disease frequently occurs at forty years or even less.

Pathology The common sites for a neoplasm to arise are in the pharyngo-œsophageal area at about the level of the aortic arch and above the cardia. The growth is usually of the squamous-celled type but at the lower end columnar-celled carcinoma may be found, having spread up from the stomach Growth involves the whole circumference, and sooner or later ulcerates direct outward spread leads to perforation of the trachea pleural cavity or rarely one of the large vessels. Involvement of a recurrent laryngeal nerve in growth causes one-sided paralysis of the larynx, with changes in the voice the left side is more often affected than the right. Secondary deposits appear in lymphatic nodes both mediastinal and abdominal.

Symptoms There is gradually increasing dysphagia, first for solids only and later for liquids as well. There is often a feeling of obstruction and occasionally regurgitation of food is complained of Pain is uncommon except with post-cricoid growths, when it may appear early and be of severe type referred to the ear along the course of Jacobsen s nerve. Collection of frothy saliva in the pharynx worries the patient, particularly as there is often

overflow into the larynx, with resulting cough this symptom is most troublesome in cases where one recurrent laryngeal nerve is paralysed, because of inefficiency in lateral protection of the laryngeal aperture by the aryepiglottic fold. A cervical œsophageal growth may sometimes invade the thyroid gland and present as a neoplasm of that organ



FIG 42 5 CARCINOMA OF THE ŒSOPHAGUS.
Note the filling defect and the holding up of the barium column, but with no appreciable dilatation.

With growths of the mid or lower œsophagus it should be emphasized that dysphagia is the sole symptom and that the slightest degree of this demands the most careful attention and investigation by radiography and œsophagoscopy The skiagram of a malignant stricture is very typical the barium being held up in the portion above it. On screen examination the upper level is seen to rise and fall. A broken thin, irregular stream is seen gradually passing through the stricture, but when once below it rapidly passes into the stomach. In cancer the œsophagus is never greatly dilated as in cardiospasm. An œsophageal bougie must not be passed *blindly* in any case of suspected malignant disease if dilatation is attempted, it must invariably be under vision, for in most cases the lumen of the œsophagus is well away to one side of the growth. It is by no means difficult to perforate

the walls of a diseased œsophagus and open up the mediastinal tissues causing thereby a fatal cellulitis. The use of the œsophagoscope enables the upper part of the stricture to be seen and a piece to be taken for microscopical examination if desired an absolute diagnosis can thus be made.

Treatment (1) *Post-cricoid Growths* If such growths can be diagnosed reasonably early the treatment consists of excision of the upper segment of the œsophagus and reconstruction of the gullet by a skin tube, according to Trotter s method. When the disease is extensive as is usually the case the larynx must be removed together with a segment of the œsophagus and pharynx primary repair is practicable a plastic tube joining the divided pharynx to the œsophagus, with a skin graft wrapped round it to form a new lumen Pharyngo-laryngectomy is a severe operation and it is advisable to combine it with block dissection of the cervical lymph nodes, removing

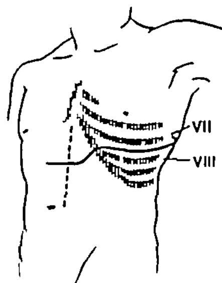


FIG 42 6. ABDOMINOTHORACIC INCISION FOR EXCISION OF CARCINOMA OF THE ŒSOPHAGUS.

The incision divides the left rectus muscle transversely and passes along the seventh intercostal space. As an alternative a left paramedian incision may be made.

the sternomastoid muscles and one or with an interval both, jugular veins. The closure of the deficiency is a plastic procedure which may need to be done in several stages.

Treatment by telecurie therapy or high-voltage X rays is an alternative to surgery and some successes have been reported.

(2) *Intrathoracic Growths* The radical excision of an œsophageal neoplasm is a major surgical undertaking. Since the patients are nearly always old and poorly nourished and as the operation is of necessity severe, the overall results are poor The approach may be entirely thoracic through the seventh interspace or the bed of the seventh or eighth rib an abdomino-thoracic incision which divides the costal margin, usually in the seventh space may be used or separate thoracic, abdominal and cervical incisions may be employed. Most surgeons agree that the best approach to the cardia is from the left side, while for the mid-œsophagus views are divided as to whether the right or left approach is the better The azygos vein on the right can be ligated whereas the aortic arch on the left cannot and tends to

obscure the field It is the direct extension of the tumour into the structures of the mediastinum which may make excision impracticable and if both pleural cavities have to be opened the operative mortality is higher With cardiac (*i.e* lower-end) neoplasms the scope is greater and a block excision of most of the stomach with its regional nodes, the omentum and the spleen may be performed. Continuity is restored by mobilizing the stomach (or utilizing the jejunum if the stomach has been removed) and anastomosing it to the divided œsophagus After division of the left gastric and gastro-epiploic vessels it is surprising how far up into the chest or even into the neck the stomach can be drawn.

Palliative operations are also sometimes indicated. Gastrostomy is often performed but the relief so obtained is often unsatisfactory as the totally obstructed patient is unable to swallow his saliva. Short-circuit operations between the stomach or jejunum and the œsophagus proximal to the growth are often feasible and may bring much comfort to a patient. Other palliative methods which may be employed are dilatation of the growth stricture under direct vision (though the danger of perforation must be borne in mind) and, combined with this, the insertion of a Souttar's tube which is made of spirally coiled stainless steel wire and the upper end of which is expanded to fit into the top of the stricture. Patients can usually swallow sufficient nourishment through such a tube to avoid the necessity for gastrostomy



FIG. 42 7 SOUTTAR'S TUBE.

Radiotherapy is of considerable value especially in palliation in the treatment of œsophageal cancer In the past the difficulty has been to obtain a sufficient dosage to the tumour without burning the skin But contemporary apparatus and techniques, using supervoltage X ray machines and multiple ports of entry make this possible. Implantation of radon seeds through an œsophagoscope or the use of radium needles attached to a bougie are methods which may be used with advantage on occasion.

Chapter 43

ABDOMINAL SURGERY PERITONITIS

General Principles

The success attending abdominal operations is dependent not only upon the operation itself but on meticulous attention to pre and post-operative care. First, it is essential that every possible endeavour be made to arrive at a diagnosis so that the incision may be correctly placed and the operation partially planned before starting. Only when all investigations have failed to establish a diagnosis is an exploratory laparotomy justifiable.

The most painstaking physical examination of the patient and a full enquiry into his story occupation and family history is at least as important as the more specialized investigations such as skiagrams fractional test meals, gastroscopy and any of the other adjuvants to diagnosis.

Every effort must be made to make the patient as fit as possible for his operation, although on occasion (*e.g* when a viscus is perforated) the operation itself is the most important part of the treatment and nothing should be allowed to delay it For example, a thorough examination may reveal an anæmia which pre-operatively can be treated by iron or if necessary by blood transfusion or a bronchitis that may be improved by breathing exercises being instituted so that after the operation when the pain of the abdominal wound tends to inhibit full inspiration the effect is reduced to a minimum by previous training.

It is not necessary and may be harmful to purge patients violently before operation. Provided a normal daily motion is maintained this is all that is required. An enema may be desirable on the morning of the operation to ensure that the lower bowel is empty if surgery of the anus, rectum or colon is contemplated

Attention to oral hygiene is desirable before any major operation in order to eliminate a possible source of infection and prevent the post operative complication of acute parotitis. Patients are also much better able to eat and chew their food properly if they have sound teeth or well fitting dentures

The abdominal wall is usually shaved and washed and if possible, the patient takes a bath Some surgeons like to have the skin painted with an antiseptic solution such as tincture of iodine on the day before operation but this is much less commonly called for nowadays. Particular care should be given to the umbilicus as dirt often accumulates there.

No food or drink should be allowed by mouth for four clear hours before operation and if requested by the anæsthetist, for six hours beforehand. The reason for this is the risk of the patient inhaling vomit during the induction of the anæsthetic, a complication which on rare occasions can prove fatal. The patient is requested to pass water just before leaving

for the operating theatre. If unable to do so a catheter is passed and if for any reason this is not practicable, it is important that the surgeon be informed that the bladder is not empty

The patient should be warmly wrapped in clothes that can be readily removed in the operating theatre to expose the abdomen. The operating theatre itself should be warm, a temperature of about 70° F being generally considered suitable, with a humidity not exceeding 70.

Premedication is always desirable and helps patient, surgeon and anæsthetist alike. The patient is made more comfortable and anxiety is allayed anæsthesia is more smoothly and rapidly induced and, finally by drying up the bronchial secretions the risk of post-operative pulmonary complications is greatly diminished Omnopon 20 mg. (gr $\frac{1}{3}$) and scopolamine 0·4 mg. (gr $\frac{1}{150}$) given 1½ hours before operation, subcutaneously is a well tried and effective form of premedication but morphine 10 mg. (gr $\frac{1}{6}$) and atropine 0·6 mg. (gr $\frac{1}{100}$) act more quickly and can be given between half and one hour pre-operatively When the operation must be performed urgently the anæsthetist may be willing to dispense with these drugs and merely give a single intravenous injection of atropine before starting the anæsthetic. General anæsthesia combined with muscle relaxants is ideal for abdominal work allowing wide exposure with minimal retraction and handling of the tissues, thus keeping shock to a minimum.

If the patient is in a very collapsed state beforehand as in emergency work, *e g* perforation of the stomach, it is often advisable to maintain an intravenous saline infusion throughout the operation or a preliminary intravenous saline infusion or a whole-blood transfusion may be desirable.

As a general rule the patient lies flat on the table, but if the operation involves the pelvic viscera, the *Trendelenburg position* is often adopted in which the patient is placed with the head considerably below the rest of the body All modern operating tables are provided with arrangements for the rapid and easy adoption of this position. Care must be taken to see that the arms are not kept above the head or radial nerve paralysis may follow the arms are best placed under the patient's buttocks or close to the sides. When muscle relaxants such as curare or Scoline are used and the patient is placed in the Trendelenburg position great pains must be taken to see that the arms are in no way fixed or a lesion of the brachial plexus may result The problem of fixing the patient in this position is best solved by using pelvic supports or a special corrugated rubber covering to the operating table which prevents the patient from slipping.

Antiseptics are carefully avoided in intraperitoneal operations after efficient sterilization of the hands of the surgeon, his assistants and of the skin of the patient nothing is employed in the shape of lotion except sterilized normal saline or Ringer solution. Instruments are previously boiled and counted swabs, each with a long tape are best done up in packets of a dozen wrapped in gauze It is thus easy to keep a count of the number employed. An additional worthwhile safeguard is for all gauze swabs and packs to have a fine metal strip or wire incorporated in them, then in the rare event of one being left in the abdomen at operation, this can be rapidly checked by X-raying the patient. Gauze strips for packing, abdominal cloths, etc. are dealt with in the same way a careful record of the number employed must be made before and after operation and the surgeon informed before he finally closes the wound.

Parietal Incision. In planning the incision for any abdominal operation three desiderata have to be kept in view

(1) Suitable *access* should be provided to the part to be explored a longitudinal incision near the middle line gives good approach in the majority of cases where a general exploration is desirable and in many other conditions it is most useful Transverse incisions in the abdomen are in increasing favour today because they combine excellent exposure with sound and relatively pain free healing Their only disadvantage is that they take somewhat more time to close than the vertical incisions. When dealing with such structures as the appendix or gall bladder, an incision placed transversely is particularly convenient It is always well to remember that incisions should not be placed too near to the bony or cartilaginous boundaries of the abdominal wall

When considering an emergency laparotomy *e g* for intestinal obstruction, it may not be out of place to quote here an aphorism "make the incision twice as long as you think necessary you will then not need to enlarge it very much."

(2) It must be so placed as to ensure an *effective blood supply* and thereby avoid as far as possible the risk of defective union or of post-operative hernia. Naturally the middle line, from this point of view is not desirable and the linea semilunaris is even worse Particularly is this the case when the linea alba has been stretched and the recti muscles separated one from the other Perhaps the best incisions from this point of view are those which pass *through muscular fibres, splitting and separating but not dividing them* McBurney s incision for the removal of a quiescent appendix is of this nature it gives a sufficient approach when there are no adhesions and when the appendix is not displaced. A paramedian incision with displacement outwards of the rectus is also useful taking the place of the old middle line incision, the peritoneum being opened through the posterior sheath of that muscle

(3) A point to which considerable attention has been given in recent years is the *nerve-supply* of the abdominal wall As far as possible incisions should be planned so as to avoid division of the motor nerves, especially those going to the rectus abdominis, inasmuch as paralysis of this muscle may result in considerable discomfort, and loss of tone of the abdominal wall may follow From this point of view an incision through the linea semilunaris is one of the worst that could be devised, the paramedian incision, with displacement of the rectus outwards, is better and transverse incisions are best.

The muscles and aponeuroses should always be cleanly divided and it is wise to see that bleeding is stopped before opening the peritoneum. In most cases, especially where there is a considerable quantity of subcutaneous fat, towels should be attached to the aponeurosis of the muscles, these serving to prevent any infection of the wound edges during manipulation The peritoneum can usually be picked up by dissecting forceps and opened with scissors or a knife air rushes into the cavity and it is easy to secure the margins with Spencer Wells or other forceps. Holding these well up the incision can be prolonged up or down as far as may be considered necessary

The intestines must be carefully guarded during the intraperitoneal portion of the operation and if they have to be withdrawn from the abdomen,

they should be wrapped in cloths wrung out of warm saline solution It is the assistant s duty either to replace these from time to time by other warm cloths, or better to keep them moist and warm by pouring fresh solution over them. No unnecessary handling of intestine is permitted. If any infective focus is to be opened or the intestine incised, the surrounding parts must be carefully protected from infection by "walling off the area of operation this is effected by surrounding it with abdominal cloths of suitable size and material, or by placing packs in directions where pus or other fluid might gravitate. A record of these must be kept and it is wise to have tapes attached to each one and never to cut any of them into smaller pieces. It is undesirable to use dry gauze for this purpose as it is likely to stick to the intestine and its removal may abrade it.

Closure of the Wound. A careful survey of the peritoneum must be undertaken before the abdomen is closed. All bleeding is stopped and blood-clot removed swabs are counted and, if thought necessary the site of operation cleansed with sterilized saline solution at a temperature of about 105° F

Many different methods of closing the parietal incision have been adopted but perhaps the best consists in first securing the peritoneum by a continuous catgut stitch The muscular coats are next approximated by deep interrupted stitches usually of catgut which remain buried finally the skin is united by means of a continuous suture of silk, which is subsequently removed by interrupted silkworm gut or silk stitches, or by Michel's clips. In recent years the use of non-absorbable material such as nylon or very fine gauge stainless steel wire has become popular for closing the rectus sheath It is often advisable to put in some deep tension sutures, especially where clips are used, passing, in the case of a paramedian incision, through the anterior rectus sheath In order to avoid these stitches cutting through the skin, before being tied they are often threaded through a small piece of fine loose rubber tubing which serves to distribute the pressure on the skin surface over a larger area. In some cases it is difficult to secure the peritoneum separately and then it is well to include everything except the skin by deep interrupted sutures. If the abdominal wound has to be closed urgently as for example when the patient s condition suddenly deteriorates, these through and through sutures may traverse the whole thickness of the abdominal wall including the skin.

Drainage. This is not usually called for in abdominal operations. If the surgeon is careful in his manipulations and avoids measures which are liable to lead to subsequent oozing, the peritoneum may be closed with safety When adhesions likely to bleed have been divided, or raw surfaces left such as occur after enucleating a parovarian cyst from the broad ligament some means should be provided whereby any considerable effusion of fluid can escape This can often be effected by the use of a rubber tube for twenty-four hours in which a strip of aseptic gauze is placed to act as a lampwick and along which by capillary action the effusion finds its way into the general dry dressing placed over the wound

On the other hand when an infected focus has been opened, *e g* an acute appendix abscess, drainage is essential and this is best accomplished by the use of a rubber drainage tube. A tube draining pus should not be removed until the discharge ceases but it is usually desirable to turn the tube a little each day and as the amount of pus lessens, to shorten it until it is no more required

After Treatment After the completion of the operation the patient is returned to bed with the head low The object of this is twofold first it tends to combat any shock that may be present and secondly if the patient is vomiting there is then little risk of any inhalation of the vomit This position need not be maintained for any length of time but until the patient has fully recovered from the shock of a major operation it is inadvisable to sit him up fully The mechanical effort that the heart is called upon to make is greater in this position and undoubtedly for the first twenty four hours after an operation of great severity the patient is safer and more comfortable when nursed with only one or two pillows The bed is thoroughly warmed before the return of the patient and if the latter is shocked hot water bottles in thick woollen covers, or an electric blanket separated by at least one blanket from the patient can be used to maintain body heat Over heating must be guarded against as it leads to sweating and further loss of much needed body electrolytes Whenever the general condition of the patient permits it early rising after an operation should always be practised since both physically and psychologically it sets the patient s feet on the road to recovery If practicable he should be allowed to sit in a chair for an hour the day after operation and progressively thereafter

When the degree of shock is severe and the systolic blood pressure below 90 it is best to combat the condition by intravenous infusion In all cases of shock an initial pint or two of blood is of value but this form of transfusion will only need to be continued in those cases where there has been considerable blood loss For the rest plasma and glucose saline are adequate fluids. Initially to overcome a severe degree of shock as much as 5 to 6 pints (3 to 4 litres) of fluid may have to be run into a vein within a period of two hours or so but after this the condition will be maintained by giving 5 to 6 pints in each period of twenty four hours Provided that adequate splintage of the arm is maintained it is rarely necessary to cut down on the vein and insert a cannula

Post-operative rectal infusion of tap-water is unsatisfactory owing to the lack of co-operation of the patient and the very slow absorption of the fluid It should be used to replace intravenous therapy only when the shock has been adequately controlled

In those cases where the patient on wakening from the anæsthetic is restless or in pain, an adequate injection of morphine or of pethidine must be given without delay

When the nature of the operation has been comparatively trivial as in an interval appendicectomy it is quite unnecessary to order a long period of post-operative starvation. As soon as the patient has recovered from his anæsthetic his feeds may be gently built up and his diet on the day following the operation can be regulated by his wishes.

In those cases where there has been much abdominal manipulation and exposure of the bowel the natural response of the latter is towards paralytic ileus (see p 1136) This must not be interfered with by the injudicious administration of food until it passes off in about twenty four hours. Body fluids lost during this period are replaced by intravenous administration of glucose saline or rectal tap-water At the end of twenty-four hours this may be stopped and feeds commenced by mouth if peristaltic sounds can be heard on listening to the abdomen with a stethoscope. It is always unwise to start feeding until normal peristalsis returns, unless a tube is in place and the

stomach contents can be aspirated. At first about an ounce of water is given hourly this being increased after three or four feeds to double the quantity Milk and water in increasing quantities can then be given and solids started, in uncomplicated cases, about forty-eight hours after the operation. Special directions will be found for feeding under particular conditions, such as after gastro-enterostomy where the continuity of the intestinal canal has been involved.

Gastric Suction Attention to these procedures reduces post-operative distension and discomfort to a minimum, but mention must be made of the use of continuous stomach suction as a preventive measure in those cases which are considered likely to develop ileus It has been found particularly as a result of the experiences gained in the war that if a Ryle s tube is passed into the stomach by the nasal route and suction is instituted even before the patient has recovered from the anaesthetic much fluid may be withdrawn This fluid loss must always be accompanied by adequate replacement in the form of intravenous glucose-saline infusion The glucose serves as a form of food and the saline replaces the chloride ions lost in suction Any tendency to alkalosis is thus prevented

The apparatus necessary for continuous stomach suction is quite simple An inverted bottle filled with water and provided with a rubber bung through which pass two tubes is suspended from just above the head of the bed One tube passing up to the inverted bottom of the bottle is attached to the Ryle s tube while the second tube passing only just through the rubber bung, is made to communicate by tubing with a receiving bucket on the floor As the water in the bottle falls into the bucket a vacuum is produced in the inverted bottle and as this space of negative pressure communicates by means of the Ryle s tube with the stomach, the contents of this organ are sucked out. This serves to fill up the bottle with fluid so that the process of suction is continuous. Silent electrical pumps can be obtained for this purpose and placed under the patient s bed It is important that only a few millimetres of mercury suction be employed

Treatment of the Wound. In cases where the wound is clean there is often no need to change the dressing until the stitches are removed about the ninth day If tension stitches have been inserted in addition to cutaneous approximating sutures, the former are removed about the fifth day the remainder being left till the ninth day Where Michel s clips have been employed, these should be taken off about the fourth day as their function of approximating the skin edges is then finished, but the deep sutures must be left in longer Sutures applied to the skin of the face or neck can be safely removed after four days as these tissues heal particularly quickly and scarring is less noticeable if they are removed early

In cases where sepsis is present the dressings must be changed daily and the wound treated with some mild antiseptic and in addition it is wise to approximate the wound edges by zinc oxide strapping applied to the abdomen in the form of a corset This relieves any tension caused by wriggling or distension from falling directly on the suture line and therefore tends to prevent the stitches from cutting out and the wound from gaping or even bursting.

Stitch Abscesses These are a troublesome and irritating complication of abdominal operations which may be due to faulty technique but also occur quite apart from this. The most careful sterilization of suture material

will not always prevent their occurrence and then they must be attributed either to tying a suture too tightly and strangling the tissue within its grasp or to its becoming drawn too tight owing to post-operative abdominal distension or infection of the strangled tissue or to infection of a hæmatoma They have also been attributed to the employment of sutures taken directly out of spirit which acted as a caustic All suture material should be carefully washed in sterile saline solution before using it for this purpose The trouble may start early or late and its occurrence is usually indicated by a slight but persistent rise of temperature (say to 100 F every night) associated sometimes with an increased pulse rate The external wound may apparently heal perfectly and then ten or twelve days after the operation the cicatrix yields and a quantity of pus escapes Under these circumstances efficient drainage should be arranged and it helps if the remaining stitches are removed Of course this process weakens the abdominal wall and extra precautions must be taken to prevent the formation of a ventral hernia

Intestinal Sutures. The interior of the bowel is occupied by material which, as long as it remains in its proper place is innocuous enough but should it find its way into the peritoneal cavity an acute and sometimes fatal peritonitis is almost certain to follow Hence every anastomosis made by the surgeon must be air and water tight and capable of accommodating itself to varying degrees of intra intestinal pressure It is also essential that on its peritoneal aspect the line of union should present nothing but serous membrane, as otherwise adhesions are likely to form and the normal action of the bowel subsequently may be impaired Special forms of stitches have therefore been adopted, the more important of which are described below

Lembert's Suture Originally proposed at the end of the eighteenth century this has for its object the bringing together of surfaces of peritoneum without encroaching on the mucous membrane any stitch which involves

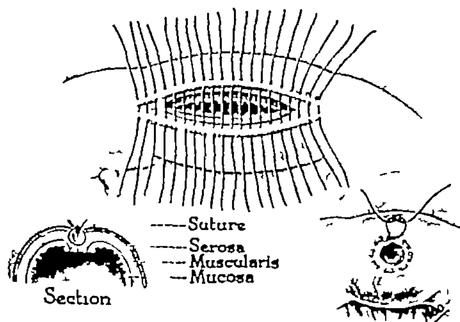


FIG 43 1 LEMBERT'S SUTURE AS APPLIED TO A LONGITUDINAL WOUND OF THE BOWEL.

the whole thickness of the wall is liable to be followed by leakage of the intestinal contents, and possibly by peritonitis. The needle is passed at right angles to the axis of the wound through a small fold of the serous and muscular coats, going down to the submucosa each fold is placed about 2 mm ($\frac{1}{12}$ inch) from the margin of the incision (Fig 43 1) On drawing up and tightening the stitch, the margins of the wound are tucked in and only the serous coats brought into apposition A series of similar stitches are inserted along the whole extent of the wound numbering about ten or twelve to the inch or it may be carried on as a continuous stitch In closing a longitudinal incision in this way a groove will be formed at either end which must

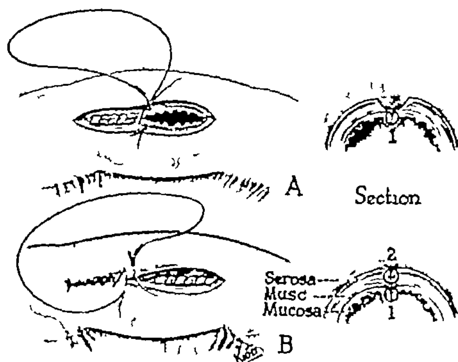


Fig. 43 2. Czerny-Lembert Suture.
A First row of sutures. B Second row of sutures.

be obliterated by two or three extra sutures For a small puncture the same type of stitch is utilized but it may be introduced circularly around the opening like a purse string, and by tightening it the margins of the aperture are turned in and buried

The Czerny Lembert Suture This is very similar in nature but consists of two rows the first has for its object the closure of the wound in the mucous membrane (Fig 43 2) and in a longitudinal wound this may be of the continuous type the second row consists of the ordinary Lembert stitches continued or interrupted according to the requirements of the situation By this means the knots of the first series of sutures are covered over and buried by the second row When carefully introduced these stitches not only serve to approximate the divided walls of the intestine but also are valuable hæmostatic agents especially if inserted continuously

Halsted's Mattress Suture This is very useful and constantly utilized

(Fig 43 3) It consists practically of a double Lembert a loop being thus formed at one end while the knot is tied at the other It is introduced with exactly the same precautions as the original Lembert

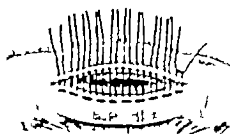


FIG 43 3 HALSTED'S MATTRESS SUTURE

Occasionally it happens that two segments of bowel have to be stitched together from inside since the surgeon cannot reach the outer coats owing to this portion being fixed Thus in an exploratory gastrotomy it may be necessary to stitch up the posterior wall of the stomach after having opened it from the front The stitches must then be inserted by what is known as *Wölfler's method* They are first passed through the serous and muscular coats on either side the knots being tied on the inner aspect *i.e* towards the lumen of the open viscus The mucous membrane is then secured by a second row of stitches so as to cover over the first series of knots In many forms of intestinal anastomosis this plan has also to be employed but as soon as possible a change is made to the Czerny Lembert method

Connell's Right-angled Suture This is a most useful suture when surfaces of some extent have to be approximated by a continuous stitch (Fig. 43 4)

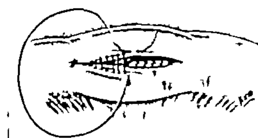


FIG 43 4 CONNELL'S RIGHT-ANGLED SUTURE.

The suture is introduced at one end of the incision and tied according to the usual Lembert method It is then carried on as a continuous Lembert suture except that the needle is introduced *parallel* to the margins of the wound and at a distance of about 3 mm. (⅛ inch) from it, instead of at right angles to it The edges are thereby tucked in very neatly Of course the mucous membrane is first dealt with separately by some form of continuous suture It may be employed very advantageously in gastro-enterostomy or any similar procedure

a skiagram is then of the greatest value, sometimes showing free air in the peritoneum under the diaphragm or the presence of a foreign body among the abdominal viscera.

Differential Diagnosis One of the most difficult differential diagnoses from an intraperitoneal injury is that of a retroperitoneal hæmatoma. When, due to a wound or severe injury gross hæmorrhage occurs between the posterior peritoneum and the underlying muscles, the abdominal signs and symptoms simulate a perforating lesion. Shock however is usually not so marked tenderness and rigidity are less and auscultation usually reveals peristaltic sounds Catheterization is employed to reveal injury of the bladder or kidney but it must not be forgotten that associated intra peritoneal injuries may also exist.

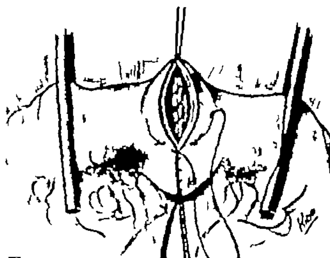


Fig. 43 5 End-to-End Suture of the Small Intestine. First row of sutures.

Treatment Except on those rare occasions when a very small injury of the liver has been diagnosed insufficient to cause serious hæmorrhage, early laparotomy is the treatment indicated Before this is carried out every effort must be made to combat the patient s shock by warmth and intra venous transfusion of blood and plasma A delay of an hour or two in making the patient fit for operation is not time wasted if he is then able to stand up to an operation from which without resuscitation, he would probably die. Only on those occasions where gross intraperitoneal hæmorrhage is occurring must resuscitation take second place to operation and, even here, there is usually time to run in a pint or two of blood At operation before the abdomen is opened, any protruding bowel is washed with saline the wound excised and the peritoneum opened. A paramedian or median incision is best employed to open the abdomen for the whole of the abdominal contents must be examined as injuries are often multiple, especially when produced by a bullet. The principles of the surgery of abdominal wounds consist of suturing lesions of the small intestine and stomach while reserving resection and anastomosis only for those cases where the bowel or its blood-supply is irretrievably damaged (Fig. 43 5) All injuries of the large gut with the possible exception of the cæcum should be exteriorized as colos-

tomies since breakdown following closure and replacement in the abdomen is not uncommon Drainage of the abdomen is seldom necessary save in hæmorrhage from the liver which may have to be controlled by packing. An injured spleen should always be removed

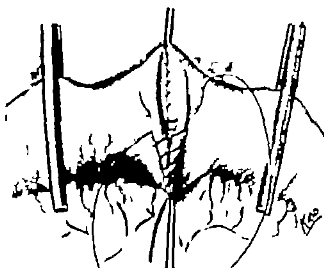


FIG. 43 6. END-TO-END SUTURE OF THE SMALL INTESTINE
Second row of sutures.

Post-operative treatment must include continuous gastric suction and the administration of sufficient intravenous fluids. Only when flatus has been passed, or the bowels have started to move should these be stopped. Penicillin and streptomycin should be given in full doses Early cleansing of the mouth and breathing exercises are of great importance. Sips of fluid of any type may be given from the start.

THE UMBILICUS

Umbilical Hernia. This very common condition in its various forms is described in Chapter 44

Neonatal Inflammation and Ulceration. These affections may arise after separation of the cord, from want of cleanliness or infection in the mother

Hæmolytic staphylococci may gain ingress to the new-born baby in this manner and lead to bacteriæmia or even septicæmia Osteomyelitis and peritonitis are two particularly lethal complications of such an infection and if contracted in hospital are usually penicillin-resistant.

Tetanus neonatorum probably owes its origin to this source, as also the erysipelas of infants, both of which diseases are usually fatal, the latter being often accompanied by sloughing of the neighbouring abdominal parietes.

Umbilical ulceration due to diphtheria is exceedingly rare in Britain (Fig. 43 7) it may be associated with diphtheria elsewhere, but is usually the only localization, tending to occur at the end of the first or during the second week of life. The general condition of these babies is not seriously affected at first and the prognosis is good, provided that it is recognized early and treatment started before the clinical picture becomes masked by secondary infection.

An eczematous like condition of the umbilicus is not uncommon and usually responds to the application of a simple dusting powder or a 1 per cent. solution of gentian violet.

Occasionally a polypoid excrescence or *adenoma* is met with, growing from the umbilicus in the first weeks of life and is probably derived from the remains of the umbilical vesicle. On microscopic examination, it is found to consist of a number of tubular glands held together by connective tissue. All that is needed is to ligature the base and cut it away



FIG. 43 7 DIPHTHERITIC ULCERATION AT THE UMBILICUS.

Umbilical Abnormalities in Adults. In adults, inflammation may result from the accumulation of dirt in the umbilical fossa, and this may even at times constitute a *calculus* giving rise to suppuration and ulceration.

In hepatic cirrhosis, with marked portal obstruction, *varicose veins* occur around the umbilicus constituting the stellate " caput medusæ " and rarely a venous hum may be heard over them through a stethoscope

Cancer of the Umbilicus. Neoplasms may be primary or secondary The former occur either as a squamous carcinoma starting in the skin as a result of prolonged irritation, or as a columnar carcinoma arising in some fœtal relic. More frequently a growth is secondary to an abdominal neoplasm such as cancer of the stomach liver or ovary Metastases from carcinoma of the breast also often occur at the umbilicus.

Umbilical Fistulæ These may be congenital or acquired. Three varieties are described according to the type of discharge

Fæcal Fistula This is of congenital origin and arises from non-closure of the vitello-intestinal duct. It opens into the intestine either directly or by means of a passage, of greater or less length, which corresponds to Meckel's diverticulum and is connected with the lower part of the ileum Sometimes this passage is closed at the intestinal end and then only discharges mucus Acquired cases are usually due to perforation of the bowel following strangulation of an umbilical hernia or to tuberculous peritonitis. A careful dissection is necessary to trace them to their origin when they are excised preferably with diathermy and the bowel end invaginated and closed securely

Congenital Urinary Fistula This is due to non-closure of the urachus occasionally merely a sinus persists, leading towards the bladder but not

opening into it It may be dealt with by excision of the mucous membrane its destruction by cautery or by freshening the edges and subsequent suture

Biliary Fistula This sometimes forms at the umbilicus resulting from an abscess connected with the gall bladder Gall-stones may be discharged spontaneously through such a fistula

THE PERITONEUM

Peritonitis. This arises from many different conditions and presents many diverse manifestations. It may be acute or chronic in its course, localized or diffuse in its distribution and protective or rapidly destructive in its results.

Ætiology Peritonitis is almost invariably due to the action of micro-organisms and the symptoms largely depend on the toxæmia they produce The bacteria light up an inflammatory reaction characterized by effusion of varying type in the mildest forms it is usually abundant and localized in the severer types it is generalized and in the worst cases death may ensue from toxæmia before there has been time for the development of any kind of localization

(1) Infection may start from any part of the *intestinal canal* from stomach to rectum. It may be due to traumatic or pathological rupture or perfor ation to the extension outwards of ulcers, to the impaction of foreign bodies, or to the damaging influence of interference with the blood-supply as in strangulation, volvulus etc. The vermiform appendix is the commonest site of onset of this group of cases. The *Streptococcus pyogenes* and *Esch coli* are the organisms most frequently present, but some of the other inhabitants of the intestine, especially those that are anærobic, are occasionally causative. The gastric contents are less noxious than those of the intestines on account of the few organisms present in the stomach as compared with those in the bowel. The initial peritonitis associated with a perforated gastric ulcer is largely irritative in nature and only later becomes infected

(2) A similar type of origin causes *puerperal peritonitis* the organisms (usually streptococci but of any pyogenic form) extending from the uterus through the lymphatics of the broad ligament, etc. to the peritoneum it is therefore possible for the infection to limit itself to the pelvic viscera.

(3) Infection may occur from *without* as in perforating wounds, operations, etc., any of the ordinary pyogenic organisms being responsible, but especially the streptococcus.

(4) Peritonitis may be due to the *gonococcus* and then has usually spread up the Fallopian tube to the *pneumococcus* and occasionally to *anaerobic bacilli* when the toxæmia is extremely profound.

(5) The *Myco tuberculosis* is responsible for the development of acute or chronic tuberculous peritonitis.

(6) Simple *chronic peritonitis* of a protective character arises when any irritative lesion of a viscus slowly approaches the peritoneal surface Adhesions of various types may result from this reaction and grave developments (obstruction, strangulation etc.) may follow at a later date.

(7) A group of cases occurs in which the cause is *mechanical or chemical* e.g extravasation of bile from a ruptured gall bladder the soiling of the peritoneum in cases of intraperitoneal rupture of the bladder or the reaction ary peritonitis occurring when intraperitoneal bleeding from for example,

the liver spleen or an ectopic gestation is taking place. Severe reaction follows such a lesion but it is possible that the focus may be shut off from the general cavity by plastic adhesions and be thereby encapsuled or absorbed or the inflammation may extend to neighbouring coils of intestine When once these become paralysed bacterial invasion is almost certain to follow

These various forms will now be considered in some detail.

Acute Diffuse Peritonitis

This condition results from infection of the peritoneal cavity by infective material (as by rupture of the stomach or intestine), or by the introduction of a small dose of virulent organisms when the resisting powers are low

Pathological Anatomy The peritoneal surface becomes congested and a little sticky and its shiny appearance is lost (as a result of the proliferation of the endothelial cells and a commencing œdema of the subserous connective tissues) This change is most advanced in the neighbourhood of the site of infection but rapidly spreads and in the gravest forms of peritoneal toxæmia, where death takes place under twenty-four hours, there is but little evidence of the disease. In the great majority of cases, however effusion occurs sometimes the fibrinous element is most marked the intestines being matted together and the fibrin thickest along the lines of contact of adjacent coils, while sometimes there is an abundant serous exudate. More frequently it is seropurulent or consists simply of pus which may gravitate to the loins and pelvis, or travel upwards under the diaphragm or be shut up in pockets by the development of adhesions. The effusion is intensely infective and any wounds caused during the operation or in post mortem examination of such a case are likely to be followed by severe cellulitis or even septicæmia. Gas may be present, resulting either from the laying open of an air-containing viscus or from the presence of a gas-producing organism.

The intestinal walls become paralysed, as a direct result of the action of toxins upon the contained nervous plexuses, in consequence the contents of the gut stagnate and undergo decomposition. The omentum becomes congested and infiltrated with effusion, or even pus it may occasionally however form a barrier across the abdomen, shutting off the lower from the upper part and limiting the infection to some particular section.

The toxins developed in the exudate are absorbed by the peritoneum and while causing a generalized toxæmia of varying severity they may also determine a well marked subperitoneal œdema. The rapidity of absorption is very considerable, especially from the under surface of the diaphragm where the lymphatics are practically continuous with the peritoneal cavity and quickly carry toxins and bacteria to the mediastinal lymph nodes. The upper half of the abdomen is therefore a less favourable site for infection than the lower and all available means, such as position drainage etc. must be employed to limit its extension upwards.

Symptoms The onset varies somewhat with the cause of the infection, but when due to traumatic infection from without, the symptoms usually start with abdominal pain and rigidity followed by distension, together with flatulence and vomiting. The pain may be localized at first to some particular region, or be referred to the umbilicus soon, however it becomes diffuse and is associated with exquisite tenderness and great distension. In an advanced case the clinical picture is characteristic. The patient lies

on his back with the knees drawn up partly to relax the abdominal muscles and partly to prevent the bedclothes touching the body The abdomen is distended hard and extremely tender It is at first generally tympanitic, but later if effusion should become marked, dullness may be noted in the flanks, although this is not a common feature. The pulse is quick with a big pulse-pressure in the early stages, though later it becomes weak rapid and of low tension The respirations are quick shallow and thoracic in character The temperature perhaps raised at first as a result of the causative lesion, sometimes becomes subnormal from toxæmia before the patient dies Vomiting is usually a prominent symptom associated perhaps with hiccough to start with, the contents of the stomach alone are expelled, but later they may be mixed with bile or with the decomposing contents of the upper coils of intestine. Though very constant and troublesome it is much less distressing than that which arises from intestinal obstruction and owing to the pain induced by any sudden contraction of the abdominal muscles, the patient ejects the vomit with but little force. Constipation and the absolute arrest of flatus are almost always present in peritonitis owing to the cessation of peristalsis induced by the inflammation Hence meteorism is marked. On auscultation the abdomen is absolutely silent. As the disease progresses the patient s strength rapidly diminishes, his face becomes pinched and drawn (*facies Hippocratica*) the extremities cold, the temperature subnormal and death results from collapse and toxæmia.

When peritonitis is due to a sudden perforation of the bowel, the onset of symptoms is associated with profound shock and the course is very rapid if the opening is large. Vomiting, also is usually more marked than when due to other causes. If however the perforation is small the immediate shock is less and the symptoms progress more gradually

Treatment In the early stages, if the diagnosis is in doubt or the desirability of operation is in question, the patient is kept quietly in bed, preferably in what is known as Fowler's position (Fig. 43 8) *i.e* with the head and trunk raised from the horizontal plane about 30° or 40° so as to encourage the flow of fluid down towards the pelvis rather than backwards into the paracolic gutters whence it may spread up to the dangerous subdiaphragmatic area. Whether this position really encourages the gravitation of fluid towards the pelvis is a matter of dispute. No food is administered by mouth and no purgative given the lower bowel may be emptied by enema and subsequently saline is given intravenously Morphine and opium are used with the utmost caution as long as the diagnosis is uncertain, for fear of masking symptoms by lessening the pain and vomiting and thus delaying a necessary operation. Occasionally and on those rare occasions when no facilities exist for operation, these drugs may be useful in localizing the trouble and allowing adhesions to form. While the patient is being prepared for operation and the necessary arrangements are being made, a moderate dose of morphine may save him much suffering and help to conserve his powers.

The actual scope and particular features of the operation vary naturally with the many causes that may have been operative in determining the outbreak of the condition, and these will be suitably referred to later It is only possible here to deal with the general features The incision is generally median or paramedian in type and the lower half of the abdomen is opened rather than the upper unless the latter is distinctly indicated. The objects of the operation are threefold (*a*) To find and deal with the cause of the

affection such as a perforation which needs to be closed or a gangrenous appendix which must be removed (b) To clean the peritoneum and remove the effusion, and for this purpose a sucker is invaluable. The surgeon must make certain that there is no retained collection of exudate in the pouch of

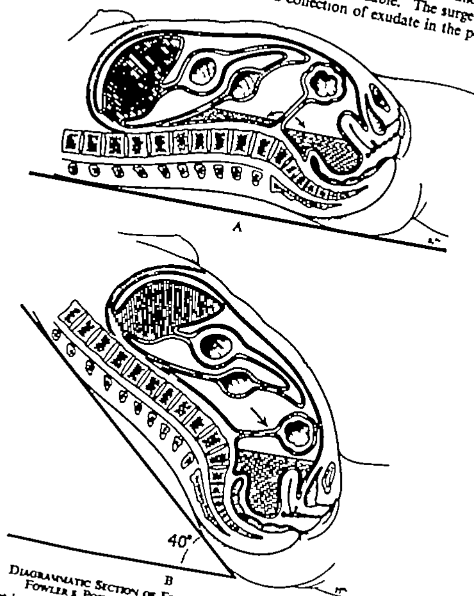


FIG. 43 8. DIAGRAMMATIC SECTION OF FEMALE ABDOMEN TO SHOW THE VALUE OF FOWLER'S POSITION IN THE TREATMENT OF PERITONITIS.

A. The patient is horizontal and it is obvious that an inflamed appendix lying over the brim of the pelvis will cause effusion, which drains in two directions upwards towards the liver and diaphragm and downwards to the pelvis.

B. If the patient is in Fowler's position the resulting effusion will collect in the pelvis.

Douglas or in the right paracolic gutter after a perforated duodenal ulcer. If there is, the collection must be carefully mopped or sucked away. The peritoneum has a great power not only of absorbing fluid, but also of destroying bacteria and hence if the primary focus of trouble is satisfactorily removed or dealt with, may be largely left to defend itself (c) At the same time

drainage is necessary in many cases where a collection of fluid has formed in the pelvis this may be effected by the use of rubber tubes with or without gauze wicks or by a cigarette drain This tube should be rotated after forty-eight hours, and thereafter gradually removed as the discharge diminishes sufficiently The abdominal wall is of course only partially closed after these procedures. Experience however has shown that the peritoneum has considerable antiseptic and defensive powers and that where the exudate is merely seropurulent, drainage may often be omitted granted that the case is an early one and that the local causative focus is efficiently treated.

When intestinal distension is very great so that it may be difficult to reach the cause of the trouble or to return the extruded viscera, it may be advisable to tap a coil of small intestine and empty the contents or to stitch in a rubber tube and allow the bowel subsequently to empty itself dealing with the fistula so produced at a later date. The reduction of the distension is essential if a successful issue is to follow but undue manipulation must be avoided. The value of the intraperitoneal use of chemotherapeutic agents such as the sulphonamides, penicillin and streptomycin is not yet finally decided. If adequate dosage is given parenterally the drugs will be carried to the site of infection by the blood stream and no risk is run of peritoneal irritation leading to adhesions.

In view of the mixed nature of most infections of the peritoneum it is well in all cases to give the patient post-operatively a course of penicillin and streptomycin, penicillin and a sulphonamide, or one of the tetracycline group of drugs for four to six days, or longer if the disease warrants it.

As soon as the patient has recovered from the anæsthetic, he should be raised from the recumbent to the sitting posture (Fowler s position), with a view to permitting the fluid effusion to gravitate into the pelvis. It will be found that all cases of acute general peritonitis are benefited by being placed on continuous stomach suction and intravenous replacement of fluid for several days Vomiting is prevented thereby and the severe post-operative complication of paralytic ileus is reduced to a minimum. Improvement in the condition of the patient shows itself almost at once by a fall of temperature and of the pulse rate the vomiting ceases or becomes less urgent, pain and tenderness decrease and the patient looks and feels better In many cases flatus is passed at the end of three or four days and at this time the bowels should be encouraged to work with a glycerin suppository or enema, so long as the operation has not involved the large bowel The stomach drainage will now consist only of bile-stained fluid this replacing the pints of dirty brown fluid that previously have been withdrawn. When this change occurs the Ryle s tube may be removed and the intravenous drip stopped fluids being started by mouth. As soon as the bowels have acted well it is probable that the patient will recover

Acute Localized Peritonitis

This usually arises in connection with some limited lesion of the abdominal contents, which may be of such a nature as to permit of the general peritoneal cavity being shut off by adhesions, thus localizing the process. It is frequently followed by suppuration, the abscess being intraperitoneal although not involving the general peritoneal cavity The abscesses arising in connection with appendicitis or pelvic peritonitis are commonly of this nature. They may burst through the barrier of adhesions and light up a diffuse inflammation

of the peritoneal sac, or they may burrow to the surface and point externally or open into one of the hollow viscera.

Symptoms There is deep pain and tenderness more or less localized to the affected area, together with fever vomiting and constipation. At first no swelling or tumour is to be made out but a feeling of resistance may be noticed in the abdominal wall which is held tense. As the effusion increases in amount, a tumour dull or tympanitic on percussion, may become evident It is mainly due to a matting together of the intestines and omentum, but is often associated with a variable amount of fluid If however it is placed deeply the dullness may be absent owing to the fixation of one or more coils of intestine in front of the inflammatory focus. If an abscess forms and travels towards the surface, the abdominal wall becomes infiltrated, red and œdematous, the component tissues being brawny to the touch and cutting like bacon This process is attended with considerable increase in the pain and constitutional disturbance Finally a fluctuant area presents itself in the middle of this indurated mass and the abscess either discharges itself or is opened. The pus contained therein is often offensive owing to the presence of *Esch coli*

If the cavity is opened aseptically and drained, it rapidly contracts and a cure is accomplished although intraperitoneal adhesions may persist and lead to subsequent trouble by hampering the intestinal movements The determination as to the existence or not of suppuration is by no means easy and a white blood-count, perhaps repeated more than once is often of value.

Treatment In these cases resolution can sometimes be obtained by keeping the patient absolutely quiet and on a very light diet. Morphine given in small doses *i.e* 8 to 10 mg. (⅛ to ⅙ gr) comforts the patient and may aid peristalsis. Large doses of morphine are contra-indicated as they inhibit bowel action. A simple enema is administered and hot fomentations applied to the abdomen are soothing. Such a course must, however not be persisted in for too long when suppuration is likely to have occurred, for fear of the inflammation spreading to the general peritoneal cavity or of the abscess bursting into it. If the abscess can be accurately located, it should be drained by an incision which is made as near as possible directly over it. When this is not possible an exploratory laparotomy is carried out.

Simple Chronic Peritonitis

This rarely requires surgical attention since it is to be looked on rather as a protective than as a destructive process It is characterized by infiltration and thickening of the peritoneum whereby the intestinal wall is strengthened and bacterial invasion hindered. It is localized or diffuse in character and arises as the result of some pre-existing inflammation In the more diffuse forms the intestines may be hopelessly matted together or the omentum rolled up and contracted into a rounded cord-like mass lying transversely across the upper part of the abdomen chronic obstruction is almost certain to arise sooner or later from this condition.

More frequently it is the consequence of some localized injury or inflammation In the former plastic lymph is deposited over any breach of continuity of the serous membrane, and to this the omentum or intestine becomes adherent the under surface of a laparotomy wound may be affected in this way Localized areas of inflammation are similarly liable to originate

adhesions which are thus found in connection with gastric ulcers, an inflamed vermiform appendix, enlarged mesenteric lymph nodes or a pyosalpinx. Under favourable circumstances many such adhesions are absorbed in the early stages, but if they persist they are modified by the intestinal movements and are likely to become lengthened and rounded thus originating the bands and cord-like structures so often the causes of acute obstruction The omentum is frequently involved in this process and thereby constitutes one of the most important agents for checking the spread of inflammation. Intestinal adhesions often give rise to no symptoms but sometimes they determine attacks of colic and of irregular peristalsis, accompanied perhaps by vomiting and constipation.

Treatment In all cases every attempt should be made to cure the condition by conservative methods, as if laparotomy is performed and an adhesion divided there is still every likelihood that it will subsequently reform, so that the cure is not permanent. Treatment therefore resolves itself into rest in bed, a fluid diet, enemata and, if necessary stomach suction. Most cases may be tided over by these methods and only if the obstruction increases will operation be necessary

Tuberculous Peritonitis

This disease is almost limited to young people and is usually secondary to some other focus of tuberculosis, *e g* in the intestine, mesenteric lymph nodes, Fallopian tube testis, etc. It is sometimes confined in its development to a portion of the peritoneal cavity especially when originating from the pelvis or appendix, but is more frequently diffuse. In Britain it is now a very rare condition due to the marked decrease in incidence of tuberculosis.

Pathology Three different types occur which may be associated with or follow one another

(1) *Ascitic Type* In this variety the peritoneum becomes thick and hyperæmic and is studded with tubercles some of them small, grey and translucent, others larger and undergoing caseation. The effusion is generally abundant and consists of straw-coloured or opalescent serum, occasionally blood-stained in the more active cases. Flakes of fibrin may be found covering the membrane here and there but there is no extensive matting of the intestines. Occasionally the effusion becomes *encysted* giving rise to localized fluid swellings shut in between the coils of intestine.

(2) *Fibrous Type* Here the intestines are matted together by extensive adhesion and between them foci of tubercle are found. The mesentery may become infiltrated and shrink, fixing the intestines back *en bloc* to the posterior abdominal wall. The omentum is often invaded and contracts upwards to form a sausage like tumour lying transversely above the umbilicus. There is but little effusion and that is usually encapsulated. It is obvious that such a condition is very likely to lead to obstructive phenomena, due to kinking of the intestine.

(3) *Suppurative Type* This is characterized by the presence of tuberculous foci of some size between the coils of intestine caseation and suppuration follow and the abscesses are likely either to open into the intestines, possibly into two coils, causing thereby a fistulous communication (*fistula bimucosa*). Occasionally the infection tracks to the surface and opens externally most frequently at the umbilicus, giving rise to a fæcal fistula.

In each of these varieties acute manifestations may develop at any time

as a result of infection from the bowel with *Esch coli*, when the symptoms of acute diffuse peritonitis may supervene

Symptoms These are extremely variable and the early stages of the disease are sometimes not easy to recognize

A few cases have an *acute* onset with abdominal pain and distension and continued pyrexia of a mild type. The abdominal wall, however is rigid and there is well-marked tenderness, often localized to the right iliac fossa and simulating acute appendicitis Free fluid is present and though vomiting and constipation exist they are not marked features. The patient does not look so ill as the local symptoms would suggest but naturally goes down hill and wastes quickly A careful examination of the pelvic viscera should always be made in girls and young women, as this condition is not an uncommon complication of genital tuberculosis.

In the more *chronic* forms the earliest symptoms are weakness with some slight abdominal discomfort and diarrhœa alternating with constipation. The temperature becomes of a hectic or remittent type and periods of improvement may alternate with attacks of increasing pain and weakness. On the whole the patient gradually gets worse, his wasted frame comparing markedly with the protuberant and enlarged abdomen. The phenomena discoverable on abdominal palpation vary considerably with the conditions present within.

Treatment In the early stages and especially in the acute variety treatment is often successfully undertaken by the physician and the introduction of the anti-tuberculous drugs streptomycin,isoniazid and para aminosalicylic acid, has immeasurably improved the prognosis Hygienic measures of the sanatorium type are adopted the patient living in the fresh air and of course being always in the recumbent position Plenty of good digestible food is given and cod-liver oil is of value

It is sometimes desirable to operate especially when a chronic ascitic accumulation is present. All that is needed is to remove the fluid by laparotomy closing the wound completely in nearly 75 per cent. of such patients a cure may be anticipated In the acute forms operation is undesirable.

Sometimes operation is necessary for the relief of obstruction caused by the disease and then it is often wise to perform a short-circuiting anastomosis, as separation of the matted coils of intestine is often impossible as well as dangerous, since the obstruction is likely to reform shortly afterwards.

Pneumococcal Peritonitis

This form of peritonitis may arise as a primary manifestation or may be secondary to lesions such as pneumonia empyema or throat and ear trouble caused by pneumococci. The primary variety is usually though not always seen in girls between four and fourteen years of age but it is most unlikely that the infection spreads from the genital tract, for only occasionally are pneumococci isolated from the vaginal secretions The outbreak is sometimes preceded by slight diarrhœa, but the onset is usually sudden and definite in the shape of abdominal pain. This is accompanied by shock fever and toxic manifestations which often take the form of drowsiness confusion or sometimes delirium. Vomiting is present and the pulse is rapid. The most characteristic feature is that abdominal rigidity is generally slight. After a few days, during which the temperature remains steadily high, there is a considerable effusion of pus into the peritoneal cavity accompanied by

intermittent abdominal pain while the swelling increases although the abdomen remains soft and tumid

Leucocytosis now becomes more marked In the third stage the effusion is likely to localize itself to some part of the abdomen either as a subdiaphragmatic abscess, or one rising up in a dome like fashion from the pelvis, encroaching gradually upon the abdominal cavity Typical dullness may be noted and the patient wastes rapidly The abscess sometimes evacuates itself either into one of the viscera or externally e g through the umbilicus when a spontaneous cure may follow In the more acute cases the course is very similar to the diffuse pyococcal type described above Prostration is generally rapid if treatment is not begun the chief distinguishing features are the presence of looseness of the bowels, a high leucocyte count and a less rigid abdomen The pus is usually like that in a pneumococcal empyema being greenish-yellow in colour with a faintly sweet smell and containing an abundance of false membrane

Diagnosis This is confirmed by making a small incision preferably using local analgesia and taking a swab of the pus. This is cultured and the sensitivity of the organisms to antibiotics determined Children with nephrosis are peculiarly liable to develop this condition.

Treatment Rest in the Fowler position and the administration of penicillin or other antibiotics in heavy dosage, *e g* 1 million units penicillin intramuscularly daily is the treatment of choice. If vomiting occurs, continuous aspiration of stomach contents is carried out with a Ryle s tube and intravenous saline administered.

Gonorrheal Peritonitis

This almost always occurs in women as a direct extension of a gonococcal inflammation upwards from the uterus, being preceded or accompanied by the phenomena of salpingitis or oophoritis it has, however been known to develop in men. There is usually a definite history of gonorrhœa with a more or less abundant discharge, but the attack generally follows a menstrual period, or manipulation of the tubes and ovaries. The onset is sudden and acute, the patient complaining of severe pelvic pain which is accompanied by vomiting, abdominal distension and fever A swelling may be felt above the brim of the pelvis. With suitable treatment the trouble often abates rapidly and the patient recovers but adhesions are likely to be left, causing sterility or the tubes may remain full of pus (pyosalpinx) In other cases exudation is abundant, but the prognosis is generally favourable.

Treatment This consists of absolute rest, fomentations to the abdomen and the administration of penicillin intramuscularly at the rate of 1 or 2 million units daily If rapid improvement does not follow laparotomy should be undertaken in order to let out the pus and permit suitable drainage. The tubes and ovaries should always be explored in such patients and may perhaps need to be removed.

Subphrenic Abscess

Anatomy Suppurations which occur in the space bounded above by the diaphragm and below by the transverse mesocolon are included in the term subphrenic abscess. The space is largely divided by the liver into a superior and an inferior compartment and each of these is again partitioned into right and left, the former by the coronary ligament of the liver sus-

pending it to the diaphragm and the latter by the falciform ligament attached to the abdominal wall The right superior compartment is further divided into an anterior and a posterior division by the right lateral ligament, while the left inferior compartment is similarly divided by the lesser omentum the posterior division being the lesser sac. Six spaces are therefore present, each of which may become infected and produce an intraperitoneal abscess (Fig. 43 9)



FIG. 43 9 DIAGRAM SHOWING THE DIFFERENT PERITONEAL COMPARTMENTS IN WHICH AN ABSCESS MAY FORM.

1 Left anterior 2 left inferior 3 left inferior extraperitoneal 4, right posterior 5, right anterior

In addition two potential spaces exist outside the peritoneum the one between it and the inferior part of the diaphragm and the abdominal wall, and the other situated between the diaphragm and the peritoneum covering the right lobe of the liver Either of these may become infected giving rise to a localized collection of pus the former usually from an infection around the umbilicus, the latter from such conditions as an acute retroperitoneal appendicitis, a pelvic suppuration, or alternatively from some infection of the kidney

Pathology These six intraperitoneal spaces are affected by pathological conditions of various organs with which they are in close relation. Thus the right inferior intraperitoneal space may be infected from a gall-bladder the perforation of a duodenal ulcer or a liver abscess, and in addition is commonly infected from the appendix. Infection may be lymph borne, or fluid may track up the paracolic gutter on the outer side of the ascending colon and infect this and the right postero-superior compartment with which it is in communication (Fig. 43 9) Acute pancreatitis or a perforated

Symptoms The early symptoms of a subphrenic abscess are constitutional in type After an operative procedure, the temperature, instead of settling, is irregular raised and intermittent the pulse rate goes up and the patient shows signs of toxaemia. There is often a characteristic dry cough due to irritation of the diaphragm. Occasionally the patient may have a rigor and complain of pain over the lowest rib, posteriorly or anteriorly according to the position of the infected space Sometimes there is referred pain in the shoulder and in cases of extraperitoneal infection, pain is complained of in the loin The muscles in the upper abdomen are on guard and in some cases the liver is pushed down by the accumulation of pus on its superior surface so that its edge may be palpated If gas is present in the abscess cavity a band of resonance may be identified between the liver on the one hand and a collapsed lung on the other Sometimes there is a spread of infection through the diaphragm with the formation of an empyema and in other cases the abscess may discharge into the pleural cavity Radiographic examination is invaluable and will reveal a raised immobile diaphragm on the affected side with perhaps a fluid level beneath it The white blood count is raised.

Treatment Patients presenting these signs and symptoms have an infection of the subphrenic spaces which may or may not have gone on to suppuration In the early stages of the infection conservative treatment consisting of putting the patient in Fowler's position and administering antibiotics should be employed but if the temperature and pulse do not settle and the signs and symptoms increase operation must be performed. Aspiration, as an aid to diagnosis should only be used on the operating table so as to assist in reaching the pus by the shortest possible route

The best form of treatment is to open and drain the abscess. Posteriorly an incision is made obliquely over the twelfth rib, a portion of which is removed subperiosteally A transverse incision is then made through the bed of the rib and cuts the diaphragm below the pleural reflection. The peritoneum is then peeled up, away from the posterior abdominal wall, until the abscess is found. Anteriorly extraperitoneal drainage is instituted by making a subcostal incision and reflecting the peritoneum away from the diaphragm until the abscess is reached, when it is opened and drained.

Ascites

By ascites is meant an accumulation of fluid and that usually of a serous type within the peritoneal cavity It results chiefly from cirrhosis of the liver Bright's disease (nephritis) and various cardiac affections but is also a consequence of any obstructive pressure on the portal vein as by malignant lymph nodes in the portal fissure secondary to carcinoma of the stomach or of the intestine or by fibrous adhesions, the consequence of duodenal ulceration or stones in the gall-bladder Fluid also collects in the abdomen as the result of diffuse malignant deposits scattered over the peritoneum, or from the presence of mildly irritative foci such as hydatid cysts, etc.

Chylous ascites is a condition in which the fluid is milky from an admixture of chyle and usually results from rupture of the receptaculum chyli in consequence of the pressure on the thoracic duct of malignant nodes secondary to cancer of the stomach. *Encysted ascites* results from the distension of a portion of the cavity which has been shut off by adhesions

Signs The signs of ascites are easy of recognition. The abdomen is

distended like a barrel but with bulging flanks dullness is present in the loins when the patient is recumbent and extends forwards to about the same level all round the only resonant area being about the umbilicus, this is due to the floating forward of the intestines. On rolling the patient over to one side, the dull and resonant areas shift the part that is highest becoming resonant This sign is occasionally absent if the mesentery is short or if the intestines are tied down posteriorly On flicking the abdomen a well marked thrill is usually transmitted from one side to the other Necessarily the fluid also finds its way into any diverticulum of the peritoneum such as an unclosed funicular process or a hernial sac.

Treatment This varies with the cause of the accumulation Should it persist and the patient s breathing be hampered by the abdominal distension, removal by *paracentesis* is essential The usual plan is to seat the patient on a chair or semi-recumbent on a couch The bladder is emptied and then the abdomen is percussed and a spot of absolute dullness selected Under local analgesia a small incision is made, after cleaning the skin and a suitable trocar and cannula inserted. The median line below the umbilicus is the place usually chosen for the puncture, but there is no objection to inserting the trocar through the flanks. If it is desirable to withdraw the fluid more slowly two or three small-sized trocars and cannulæ may be inserted. The fluid removed should be centrifuged and examined for malignant cells by a pathologist for the diagnosis can often in this way be achieved

In patients in whom the ascites is clearly due to portal hypertension, an anastomosis is performed between the portal vein and the inferior vena cava (*portacaval shunt*) Where this is not possible, splenectomy is performed and the splenic vein anastomosed to the left renal vein (*splenorenal shunt*). This subject is dealt with in Chapter 47 In cases due to cirrhosis, the Talma Morison operation may possibly be of some use. The object is to relieve the obstruction to the portal system by opening up fresh communications between it and the systemic veins the method consists in fixing the great omentum to the abdominal wall to create adhesions.

The Great Omentum

The omentum is of great surgical importance in the abdomen in that it covers and protects the viscera and by its mobility is able to apply itself to many a weak spot where perforation or infection might occur thereby guarding the patient from the spread of serious inflammation. The result of this process is however the formation of adhesions which by the irritation of constant movement may stretch and become rounded and cord-like leading to various forms of intestinal obstruction (by strangulation or kinking). The value of this protective power of the omentum is recognized by surgeons in the employment of *omental grafts* to add security to a line of junction in the intestinal wall with which they are not quite satisfied. The best method to adopt is to detach the graft only partly from its former connections, wrap it round the gut and stitch it in place.

Injury The omentum may be torn and holes may be formed in it as a result of injury The immediate symptoms are pain and shock, and the signs those of intraperitoneal hæmorrhage. It is also likely that other injuries coexist. At a later date a hole may be the site of internal strangulation.

Acute Inflammation. This usually occurs as a result of direct spread of infection from some other focus in the abdomen. The progress varies

with the virulence of the organisms, an acute diffuse peritonitis perhaps resulting. In the milder forms a localized inflammatory disturbance follows with all the signs of a localized peritonitis suppuration may ensue and a large intraperitoneal collection of pus develop.

Torsion of the Omentum. This is an occasional complication of an irreducible hernia and usually occurs on the right side The lesion generally follows some heavy strain and results in venous stasis effusion of a blood-stained fluid the formation of extensive adhesions and possibly gangrene and general peritonitis if left long enough The symptoms often start abruptly with colicky pain in the right iliac fossa and scrotum together with constipation and sickness the hernial swelling becomes enlarged and, extending upwards from the iliac region, a sensitive mass may be detected on palpation, which is dull on percussion and sometimes reaches to the epigastrium The temperature is normal though the pulse-rate is accelerated. Treatment is obviously operative and consists in removal of the omentum.

Chronic peritonitis, whether simple or tuberculous may cause the omentum to be rolled up into a more or less solid mass, which lies transversely across the abdomen a little above the umbilicus There is usually a band of clear resonance between it and the hepatic dullness which is helpful diagnostically

Malignant Deposits. The omentum may also become infiltrated with secondary cancerous nodules which can sometimes be palpated Their presence is usually an important indication as to the undesirability of operative treatment Colloid degeneration is not uncommon in omental cancers and huge masses of this growth may be discovered at post-mortem. Omental carcinoma usually leads to a considerable degree of ascites.

The Mesentery

Wounds. Wounds may be caused by penetrating or non-penetrating injuries. They are usually associated with laceration of the intestine and the resulting phenomena will be those of hæmorrhage, followed by general peritonitis from the intestinal lesion Simple mesenteric wounds not involving the bowel are generally due to penetrating or gunshot injuries. Hæmorrhage to a varying degree may follow and if the patient lives, the nutrition of the intestine may be seriously endangered If such a lesion is found on exploration, bleeding-points must be secured and the opening in the mesentery closed but before this is undertaken, careful consideration must be given to the vascular supply of the intestine as the ligature of a main branch of a mesenteric artery may cause gangrene and necessitate resection of a portion of the bowel.

Occlusion of the Mesenteric Vessels. Apart from strangulation or volvulus, this is usually the result of embolic obstruction of the artery secondary to such conditions as auricular fibrillation endocarditis aortic aneurysm or arteriosclerosis. It may sometimes start in the veins as a thrombosis caused by portal obstruction or some infective condition such as acute appendicitis. The process is associated with acute pain and is followed by the symptoms of acute obstruction The bowel becomes engorged with venous blood and dies its lumen is often occupied by a blood-stained effusion and the passage of dark tarry stools may be noted. The peritoneal cavity contains a quantity of blood-stained serum which after a time becomes offensive The diagnosis is often discovered at operation for the obstructive phenomena when

gangrenous bowel should be removed followed by a temporary enterostomy or direct anastomosis Such poor results have been obtained by laparotomy upon these patients that expectant treatment combined with full heparinization has been advocated and a number of recoveries has been reported using this method

Mesenteric Adenitis. The mesenteric nodes are frequently inflamed in consequence of intestinal lesions, *e g* appendicitis or typhoid ulceration. No special notice is taken of this occurrence unless suppuration ensues when the abscess must be opened In less severe cases, however it is often associated with a patch of localized peritonitis resulting in the deposit of



Fig. 43 12. Calcified Tuberculous Mesenteric Nodes.

plastic lymph to this some other viscus, *e g* the free end of the omentum, the fimbriated extremity of the Fallopian tube the vermiform appendix, an *appendix epiploica*, etc., may become adherent and an adhesion may develop which subsequently leads to intestinal obstruction. The majority of intra-abdominal bands are connected at one end with the mesentery

Non-specific Mesenteric Adenitis. This condition is very common in children and young adults. It gives rise to symptoms and physical signs very similar to and often indistinguishable from, acute appendicitis. It is considered on page 1116.

Tuberculous Disease of the Mesenteric Nodes. In children this affection is known as *tabes mesenterica* It is probably secondary to intestinal infection with the bovine bacillus and when widely diffused through the mesentery is dealt with by anti-tuberculous drugs and hygienic measures. The results

of such treatment are frequently very satisfactory. Sometimes the nodes undergo calcification and this may lead to a mistaken diagnosis if a patient is examined radiographically for supposed ureteral calculus (Fig. 43 12). At other times the caseated nodes may liquefy and give rise to an inflammatory attack that may be mistaken for appendicitis, if the mesentery of the lower end of the ileum is involved. Limited masses in the iliac fossa may sometimes be amenable to surgical measures and can be removed. Rarely the surgeon has to deal with a node which has suppurated and requires to be opened. Adhesions form between the nodes and surrounding parts and intestinal obstruction may result. This is by far the commonest complication.

Cysts of the Mesentery. These cysts are not common and are usually of lymphatic origin; they may be single containing either lymph or chyle, or multiple and then constitute a *cavernous lymphangioma*. *Blood cysts* have been known and also *dermoids* which are usually located in the mesentery of the ileum.

A rounded tense intra-abdominal swelling gradually develops behind or below the umbilicus. It is freely movable from side to side and is usually accompanied by some derangement of intestinal function. When of large size, the swelling is dull but is often crossed by the affected loop of bowel; it may possibly be mistaken either for an ovarian or a pancreatic cyst. The diagnosis of mesenteric cyst is usually made on the operating table and the treatment consists in enucleation with or without removal of the affected coil of intestine.

Duplication of the Gut. This may also give rise to a cyst but this would be a thick walled structure with a mucous lining, muscle coat and peritoneal covering.

Tumours. Occasionally these arise in the root of the mesentery and behind it, especially the retroperitoneal lipoma or sarcoma. The former may grow to a large size and destroy life by its pressure phenomena; the latter though sometimes resembling the former in structure invades surrounding tissues earlier. Diagnosis is uncertain until the abdomen is opened and the question of removal is dependent on the relation of the growth to the mesenteric vessels, which must not be injured. It is seldom that a retroperitoneal sarcoma can be enucleated and therefore treatment by irradiation must be employed. This may take the form of supervoltage X-ray therapy or the interstitial implantation of a radioactive source such as colloidal gold

Chapter 44

HERNIA

Introduction

By the term hernia is meant the protrusion of some viscus from its normal situation through an opening in the walls of the cavity within which it is contained This may affect not only the abdominal viscera but also the brain and lungs, giving rise to conditions which have been already described The present chapter is limited to hernia as met with in connection with the abdomen

The most common *situations* at which hernias occur are those spots where the parietes are weakened by the transmission of such structures as the spermatic cord and round ligament (inguinal hernia) or at the entrance of the femoral canal, where the main vessels of the leg pass under the inguinal ligament (femoral hernia) or at the umbilicus (umbilical hernia) Hernial protrusions may however develop through the obturator foramen, sciatic notch, the diaphragm and in various other situations

Ætiology *Congenital Causes* These are rather predisposing than exciting in nature and must be looked for among the many malformations and conditions of imperfect development to which the abdominal parietes and contents are liable. The following are the most important (*a*) The non-obliteration of the funicular process of peritoneum, which in the male precedes and accompanies the testicle on its process downwards from the abdominal cavity to the scrotum, and in the female passes along the round ligament. The so-called congenital inguinal hernia results from this although it must be remembered that the rupture does not necessarily show itself at birth and, indeed may not appear till after puberty It is probable that most cases of acquired oblique inguinal hernia are in reality congenital in origin (Hamilton Russell). In females under the age of twenty-five, hernia into the canal of Nuck, as this peritoneal tube is called is the most frequent variety met with. (*b*) The late descent of the testis whether it finds its way into the scrotum or not, is usually associated with the formation of an inguinal hernia of the congenital type, or of some form of interstitial hernia. (*c*) Inherited weakness of the abdominal muscles and parietes, with unusual patency of the rings, will certainly predispose to this condition and, moreover there is no doubt as to the tendency of hernia to run in families. (*d*) Abnormal length of the mesentery or omentum may have some influence when other conditions are present, but *per se* can have little effect. (*e*) Extreme phimosis, by inducing forcible acts of micturition, acts as an exciting cause. (*f*) Congenital apertures occur in the linea alba or linea semilunaris, especially opposite one of the tendinous intersections in the rectus and through these one form of ventral hernia may develop (*g*) The umbilicus is sometimes imperfectly developed at birth, permitting the viscera to protrude into the base of the umbilical cord (congenital

umbilical hernia) (*h*) The diaphragm is also occasionally defective, allowing the stomach or other viscera to find their way into the thoracic cavity

Acquired Causes Hernia may result from any condition which tends either to weaken the abdominal parietes or to increase the intra abdominal pressure Thus (*a*) it may be *post-operative* resulting from the imperfect repair of the abdominal wall after laparotomy In this respect a badly performed Battle s incision, in which the nerve supply to the rectus muscle is damaged gives rise to more post-operative herniæ than a paramedian incision. (*b*) It may be the outcome of *direct trauma* and may then occur away from the hernial regions. If seen early the affected area will probably show signs of injury such as tenderness, swelling, and ecchymosis, but it is unusual for an ordinary complete hernia to develop after injury or severe strain, unless a preformed sac is present and then immediate strangulation is likely apart from this, the hernia if seen soon after the alleged accident, is imperfectly developed and in the bubonocele stage. (*c*) Much more frequently hernia is due to *chronic strain* such as occupations which involve lifting heavy weights. Prolonged and severe bronchitis and frequent straining to pass water in cases of enlarged prostate or stricture may determine the development of a hernia chronic constipation also is a frequent factor in its production, especially if the patient makes use of a closet with a high seat whereby the inguinal canals are left unprotected a patient with weak and bulging inguinal regions may with advantage use a low commode (*d*) *Relaxation of the abdominal parietes* also favours hernia, especially if associated with or followed by severe straining. Thus pregnancy brings about a stretching of the wall especially if frequently repeated and followed by imperfect involution parturition favours the development of hernia, either in the femoral region or through the linea alba In old and weakly people the abdominal wall becomes relaxed and atonic and an additional cause may be found in the slipping downwards of the mesenteric attachment, causing the intestines to occupy the lower part of the abdomen rather than the upper (*e*) *Obesity* is also a predisposing factor to hernia the accumulated fat being deposited in the omentum mesentery and subperitoneal tissue thus increasing the intra-abdominal tension Sudden removal of this fat, due to acute illness, may leave the inguinal canals unguarded and chronic strain of any type may then determine the development of hernia.

Structure A hernia consists of a sac and its contents, the sac being formed of peritoneum perhaps thickened by additional coverings, derived from the abdominal parietes and the contents being the protruded viscera.

The *sac* or peritoneal investment of an acquired hernia, is in the early stages funnel-shaped small and thin as the rupture increases in size it becomes larger partly by stretching and partly by the drawing down of fresh membrane from the neighbourhood Occasionally it stretches irregularly and becomes sacculated or even occasionally hour-glass-shaped. The sac is described as consisting of two portions—the neck and the fundus. The *neck* sometimes large and open at first, gradually becomes narrowed and is generally thickened The body *or fundus* varies much in size and shape and may undergo considerable alterations in structure

Inflammation results from injury or pressure, constituting a form of localized peritonitis if of a chronic type the sac becomes thickened and opaque as in old irreducible herniæ Acute or subacute inflammation may determine the formation of adhesions between the inner wall and the

contained viscera or between the opposite sides of the sac if no other structures interpose. Natural cure of a hernia may occasionally be produced in this way by adhesions forming across the neck of the sac or by an adherent plug of omentum occluding the communication with the peritoneal cavity The lower portion of the sac may in a similar way be shut off from the upper either by a band of adhesions or by a septum of adherent omentum this isolated cavity is sometimes the seat of a serous effusion known as a *hydrocele of a hernial sac*

The *coverings* of the sac are indurated in long standing cases and matted together especially at the neck of the sac, which is often so thickened as to constitute an important element in the production of strangulation The opening through which the hernia protrudes becomes more or less circular and so displaced that an oblique passage such as the inguinal



Fig. 44 1 Adherent Appendix in a Hernial Sac.

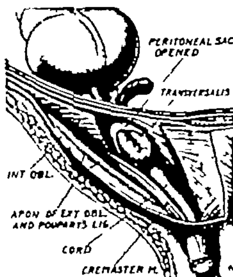


Fig. 44 2. Retrograde Strangulation of the Appendix in a Hernial Sac.

canal, becomes straight, the deep abdominal ring lying almost immediately behind the superficial

Contents. Any viscus in the abdomen may be found in the sac of a hernia, except, perhaps, the pancreas as a rule however the contents are small intestine or omentum

An *enterocele* is the name given to a hernia containing some portion of the bowel. It is at first usually reducible but if the gut becomes adherent either to the sac or to some other contained structure, it is rendered irre ducible. It may also participate in an inflammatory condition of the sac while, if irreducible, obstruction may ensue from impaction of its contents and if its vessels are constricted strangulation supervenes For a description of these conditions, see Chapter 46 The small intestine is much more fre quently involved than the large gut. The amount of bowel protruded varies from a few inches to several feet

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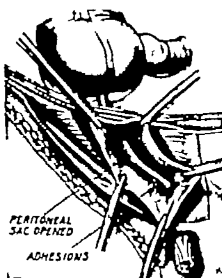


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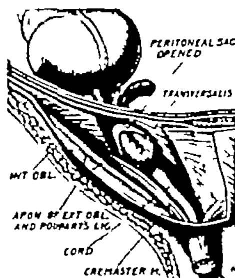


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thickened, brawny and matted together to such an extent as almost to constitute a solid tumour it is often the seat of an excessive deposit of fat and in consequence of this it may become irreducible, even when no adhesions are present. In some cases openings are found in it of sufficient size to allow the gut to pass through and become strangulated When omentum and bowel are present in the same sac, the condition is known as an *entero-epiplocele*

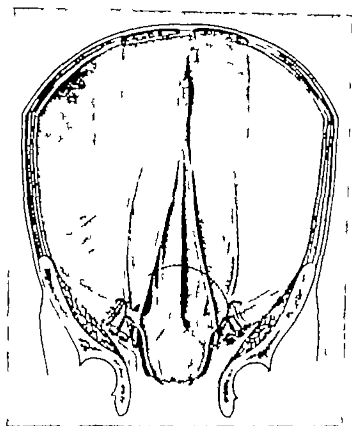


FIG. 44 3 DIAGRAM OF POSTERIOR SURFACE OF ANTERIOR ABDOMINAL WALL, SHOWING RELATION OF THE BLADDER TO THE HERNIAL ORIFICES.

The *cæcum* sometimes occupies a hernial sac, either in large herniæ or in children with congenital hernia it has even been found in a hernia of the left side. Since the cæcum has generally a complete serous covering and usually a mesentery it is freely movable and may pass into a hernial sac in the same way as any other mobile part of the intestine

The *vermiform appendix* is occasionally found in a hernial sac on the right side. It is rarely free, but generally fixed by adhesions and irreducible (Fig. 44 1) The hernia is more painful than usual and on palpation the appendix can sometimes be felt enlarged and tender pressure causing pain referred to the umbilicus. The patient is likely to give a history of recurrent attacks of inflammation in the sac. In rare cases strangulation, sometimes of a retrograde type, occurs (*Fig. 44 2*).

The *bladder* may be associated with a hernial sac in the inguinal or femoral region, the former position being the more common (Fig 44 3) Herniæ of the bladder may be divided into three varieties, according to their position in the peritoneum (*a*) extraperitoneal, (*b*) paraperitoneal and

(c) intraperitoneal Such herniæ may be primary or secondary the primary are of two types, extraperitoneal or paraperitoneal, the secondary are intraperitoneal or paraperitoneal

In the *extraperitoneal* form the anterior or lateral extraperitoneal surface of the bladder enters the inguinal or femoral canal (Fig 44 4) Fortunately



FIG. 44 4. DIAGRAM SHOWING AN EXTRAPERITONEAL HERNIA OF THE BLADDER ON THE RIGHT SIDE OF THE PELVIS AND A PARAPERITONEAL HERNIA ON THE LEFT SIDE

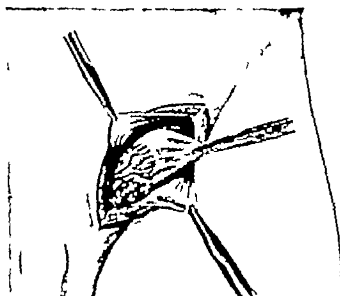


FIG. 44 5 PARAPERITONEAL HERNIA OF THE BLADDER SEEN AT OPERATION ON THE INNER SIDE OF A LEFT INGUINAL HERNIA SAC.

this is the rarest type, as in it the bladder is easily mistaken for the hernial sac and opened

In the *paraperitoneal* variety the bladder always lies on the inner side of the hernial sac (Figs. 44 4 and 5) The serous covering of the superior surface of the bladder forms the inner wall of the peritoneal sac. It is the

most common of the three varieties and the easiest to treat successfully

The *intraperitoneal* hernia of the bladder is rare and usually secondary in origin. It practically always occurs in the inguinal region. There is a complete hernial sac which is lateral to the deep epigastric artery the upper and posterior part of the bladder enters this sac and, in addition, loops of small intestine and omentum are frequently found (Fig. 44 6). Occasionally a diverticulum of the bladder may become adherent to a hernial sac and is then very liable to be laid open during an operation for radical cure. If such an accident should happen the saccule should be excised and the opening at once closed by sutures, which should not penetrate

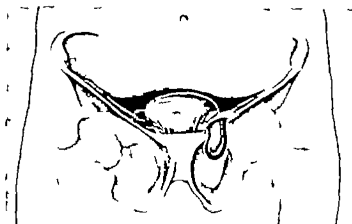


FIG. 44 6. INTRAPERITONEAL HERNIA OF THE BLADDER.

the mucous membrane. Failure to recognize this accident is followed by urinary extravasation, occasionally intraperitoneal and will require prompt treatment. The wound must be reopened, the gap in the bladder wall found and closed and effective drainage provided

The *ovary* and *Fallopian tube* are occasionally found in an inguinal hernia, more often in a child than in an adult and give rise to an irreducible swelling pressure on which causes a sickening pain.

A *Meckel's diverticulum* may enter an inguinal hernia and constitutes Littré's hernia (Fig. 44 30) Symptoms most commonly result when the diverticulum is inflamed.

Signs and Symptoms. The characteristic features whereby a hernial protrusion is recognized consist in the presence of a rounded or pyriform swelling in one of the normal or abnormal situations already mentioned, which increases in size when the patient stands coughs, or strains, having, as it is termed an expansile impulse on coughing. If intestine is present, it may be possible to obtain a tympanitic note on percussion while the tumour is tense and rounded and on pressure slips back into the abdomen with a distinct gurgle. An enterocele often gives rise to dyspeptic phenomena and perhaps colicky pains. An omental hernia feels soft and *doughy* has a less distinct impulse, or even none on coughing and is replaced without a gurgle it is dull on percussion.

Treatment. Whether this is palliative by means *of trusses, or radical,* by means of operation, it differs so greatly in the different forms of hernia that it will be described with each type separately

Inguinal Hernia

The term inguinal hernia is limited to those conditions in which a protrusion occurs into the inguinal canal and if allowed to progress finally makes its way through the superficial abdominal ring. If it extends into the scrotum it is termed *complete* or scrotal while if it does not pass beyond the superficial abdominal ring it is known as a *bubonocele* or incomplete inguinal



FIG. 44 7 OBLIQUE LEFT INGUINAL HERNIA.

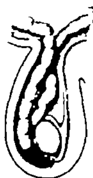
hernia. The neck is always in relation with the deep epigastric artery and the structures of the cord are either spread out over the sac or are in close proximity to it. In the early stages, the pubic spine can be felt to the outer side of the neck of the sac but as it increases in size it lies over the spine, which can be felt only after pushing the hernia upwards and inwards.

Two main varieties of inguinal hernia are described viz the oblique and the direct

Oblique Inguinal Hernia. This type (Fig. 44 7) passes down the whole length of the inguinal canal entering at the deep and emerging at the



FIG. 44 8 ACQUIRED INGUINAL HERNIA, SHOWING SEROUS SAC WITH INTESTINE COMING DOWN TO THE TOP OF THE TESTIS.





A B

FIG. 44 9 CONGENITAL INGUINAL HERNIA.
A, Vaginal variety B, funicular type.

Interstitial Hernia. This name is given to an inguinal hernia which develops in some abnormal relation to the abdominal wall. Three varieties are described. (*a*) Where a sac exists between the transversalis fascia and the peritoneum (*intraparietal* form, or *properitoneal* hernia) either with or without a hernia in the usual position. This abnormal pocket of the sac is found either between the symphysis pubis and the bladder (hernia inguinalis antevesicalis) or it extends outwards towards the iliac fossa (hernia inguinalis intra-iliaca). As no external swelling is caused by this condition it is usually impossible to recognize its existence prior to operation.

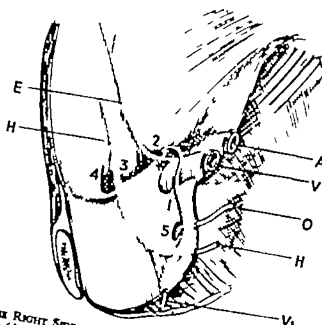


FIG. 44 12. THE RIGHT SIDE OF THE PELVIS SEEN FROM WITHIN THE ABDOMEN. The iliac vessels (A and V) are seen passing deep to the inguinal ligament and lateral to the femoral canal (1). The deep inguinal ring (2) lies lateral to the inferior epigastric artery (E). Direct hernial sacs (3 and 4) may form to one or other side of the obliterated hypogastric artery (H). The obturator artery (O) lies in relation to the foramen (5) through which an obturator hernia may sometimes protrude. The vas deferens (Vs) is indicated.

occasionally it is the cause of a continuation of the symptoms of strangulation when apparently successful taxis has been performed owing to the strangled bowel having been pushed backwards from the superficial into the deeper portion of the sac. (*b*) An abnormal sac forms between the internal and external oblique muscles (*interparietal* form) producing a swelling in the inguinal canal, covered by the external oblique aponeurosis and gradually spreading upwards and outwards parallel with the inguinal ligament. It may be associated with late descent of the testis the superficial inguinal ring being closed, so that the organ, and with it a hernia, can travel only forwards and outwards beneath the external oblique aponeurosis. Sometimes the condition is due to the existence in the sac of an ordinary oblique hernia, of a more or less complete septum at the level of the superficial inguinal ring, formed either by adhesions or by a mass of adherent omentum. The sac is then shaped like an hour glass and as the usual

downward course of the hernial contents is prevented the upper part of the sac yields laterally above the site of the obstruction and passes between the muscles (c) The hernia escapes as usual from the superficial inguinal ring but travels outwards along the inguinal ligament somewhat simulating a femoral hernia (*extraparietal* variety) This form is generally associated with late descent of the testis and a contracted scrotum so that it is easier for the hernia to pass into the thigh

Hernia-en-Glissade In certain cases of inguinal hernia the bowel may be drawn down into the inguinal canal attaching itself to and lying outside the actual sac. Usually it is the cæcum or the pelvic colon that is present and the importance of recognizing the condition lies in the fact that at operation it is in most cases impossible to separate the sac from the bowel without injury to the latter Thus, in these cases it is possible to excise the sac only as far as the lower attachment of the bowel with the result that a recurrence of the rupture is more likely to occur

Physical Signs These differ little from those already described as the general clinical features of a rupture In the early stages where merely a bubonocele exists, a fullness is noted in the inguinal canal which increases when the patient coughs it is best detected by a finger passed through the superficial ring into the canal When it becomes scrotal the swelling increases in size from above downwards and in the oblique variety is continuous with the inguinal fullness The structures of the cord are masked by the hernia but the testicle is to be felt more or less distinctly at the lower and back part of the swelling. When of the direct variety the cord lies to the outer side and although the hernia can be felt projecting from the superficial ring, it passes directly backwards and there is no fullness along the course of the canal.

Inguinal hernia is the most frequent type met with in the male sex, the oblique variety being more common in the young and the direct in elderly patients. In the female sex it is commonest in girls and young nulliparous women in such patients it is almost always congenital passing into the labium along the canal of Nuck, but rarely attaining any considerable size.

Diagnosis The diagnosis is a tolerably simple matter if it is uncomplicated by any other condition it may however be difficult and in old-standing cases it is often impossible to distinguish the oblique variety from the direct. The conditions for which it may be mistaken are best considered in two groups.

(1) *While the hernia is still incomplete and in the bubonocele stage* It has to be distinguished from the following (a) *Encysted hydrocele* of the cord, which is recognized by its smooth globular outline and tense walls although freely movable in the canal the hydrocele cannot always be entirely reduced into the abdomen, while the characteristic gurgle of a hernia is absent traction on the testis, moreover fixes the tumour and renders it immobile The exact limitation of the upper end of the swelling, if it can be reached, is very characteristic of a hydrocele. (b) A *chronic abscess* originating in the abdominal parietes, or within the abdomen or pelvis, will sometimes point through the superficial inguinal ring. In such cases, although there is a distinct expansile impulse on coughing and although the swelling is reducible, it has not the definite outline and characteristic sensation of a hernia, being usually soft and fluctuant. Other evidences

pointing to the existence of the original disease may also assist in determining the nature of the swelling. (c) *Enlarged nodes in the groin* which have become adherent to the external oblique are sometimes mistaken for a hernia, owing to the fact that on coughing a distinct impulse is communicated to them it is however merely heaving in nature and not expansile and on digital exploration of the inguinal canal, no hernia is found. (d) *A testicle retained in the inguinal canal* is recognized by that side of the scrotum being empty and on pressing the swelling, testicular sensation may be elicited The rounded upper end of the testis can often be detected. (e) *Tumours consisting of fat or other tissues* are occasionally seen in the inguinal canal but are characterized by the strict limitation of their upper border and usually by the absence of an expansile impulse on coughing. On the other hand, as described elsewhere a mass of fat simulating a lipoma is often present resulting from a protrusion of the subperitoneal tissue, a hernial sac being sometimes found embedded within it (f) *Hæmatocele of the cord* is recognized by a history of injury the presence of pain and ecchymosis, and the absence of an expansile impulse on coughing, while reduction is impracticable

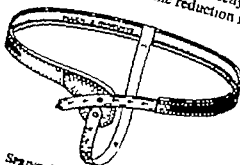


FIG. 44 13 SPRING TRUSS FOR RIGHT INGUINAL HERNIA.

(2) *When the hernia extends into the scrotum* Less difficulty is he experienced in diagnosis. By examination of the cord immediately outsid the superficial inguinal ring, all purely scrotal swellings, such as hydrocele, are readily eliminated, since in them the cord can, in the early stages be felt perfectly free A *varicocele* can also be similarly recognized from an omental hernia by the condition of the cord in its upper region, moreover if the patient is made to assume the recumbent posture the swelling disappears in each instance. If a finger is placed firmly over the inguinal canal so as to prevent any protrusion of omentum and the patient is directed to stand up the swelling immediately reappears if it is venous in character To the practised hand the diagnosis is never a matter of difficulty since the enlarged veins of a varicocele and omentum are not at all alike to the touch, the veins moving freely under the finger "like worms in a bag When a hernia is associated with a hydrocele a little more care is necessary in order to distinguish between the two swellings.

Treatment of Inguinal Hernia. This is either palliative by means of trusses, or radical, by means of operation.

Palliative Treatment A truss is an appliance which is designed to prevent by pressure the descent of the hernia. No one form is capable of dealing with every case and hence the truss must be selected with care so as to suit the special needs of the particular patient. A good truss con

sists of a pad kept in position over the hernial aperture by a steel spring (Fig 44 13) which fits the patient accurately resting behind on the middle piece of the sacrum and passing laterally midway between the crest of the ilium and the top of the great trochanter If the hernia is unilateral the spring ends on the sound side just behind the anterior superior spine and is prolonged anteriorly into a leather thong or cross strap which is secured to a stud on the pad To prevent it from slipping up an under-strap passes from the affected side close behind the anterior superior spine along the fold of the nates to the inner side of the thigh being fixed to a second stud on the pad The pad may be rounded or oval in shape and usually consists of soft metal protected by cork but wood sponge rubber or an indiarubber cushion filled with air may be employed instead It may be covered with leather and the strength of the spring must be so adjusted as to retain the hernia under all conditions of strain to which it may be subjected but without the use of undue force In ordering a truss from

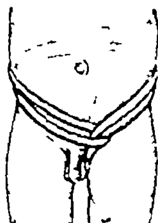


FIG. 44 14 WOOL TRUSS FOR TREATMENT OF LEFT INGUINAL HERNIA IN AN INFANT

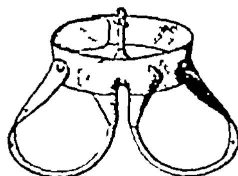


FIG. 44 15 HORSESHOE INDIARUBBER BAND TRUSS FOR INFANTS.

The pads fit around the root of the penis. The under-straps fit around the child's thighs.

an instrument maker the essential measurement is that around the body following the line taken by the truss and reaching in front to the symphysis pubis it is also advisable to indicate the size of the hernia and whether the opening of the abdominal parietes is large or small. In an early case of oblique hernia the pad should rest rather over the inguinal canal than over the superficial inguinal ring, the object being to restore the valve-like action of the canal by approximating its sides. In a direct hernia, the pad must be applied directly over the opening. It is very uncommon, though possible, for an acquired hernia to be cured in this way but in the congenital hernia of children a cure often occurs in the first months of life if the mother or attendants of the child conscientiously carry out the necessary details

In infants, an efficient support is afforded by a skein of wool (specially known as "fingering") divided at one end, so that when placed round the body the cut ends of the skein can be passed through the loop forming a knot over the inguinal canal which acts as the pad of a truss. The cut ends are now passed under the perineum and tied to the transverse portion behind (Fig. 44 14) This apparatus is changed night and morning when

the child is bathed, and also if need be at shorter intervals, the mother being instructed how to support the hernia while the apparatus is being removed. In cases of single or double rupture in infants, an india-rubber band with two pneumatic air pads or sponge rubber ones (Fig. 44 15), arranged so as to fit over the inguinal canals and with suitable straps and studs is the most satisfactory In addition to such pressure it is important to remove all causes of intra-abdominal tension as by circumcision where phimosis is present, or by regulating the bowels.

Radical Cure Operation gives excellent results if the cases are carefully selected, if the technique is satisfactory and if the after-treatment is efficient The mortality is so small as to be negligible

The selection of cases for an operation of this type which is not an essential but only a desirable means of treatment, is a matter requiring some judgment and discrimination In an individual whose occupation does not subject him to heavy strain or exertion and who possesses a hernia which, under ordinary circumstances is easily commanded by a suitably applied truss no operation is absolutely necessary although it is justifiable to urge him to submit to it, since he will be freed from the irksomeness of wearing a truss and from the possible occurrence of strangulation. If however the subject is a labouring man exposed to injury and strain, the operation should always be undertaken unless distinctly contra indicated (*a*) by a general inherited weakness of the abdominal muscles (*b*) by a relaxed and atonic condition of the abdominal parietes, which is commonly seen in elderly people or (*c*) by such constitutional disease as precludes avoidable operative intervention (*d*) Again, in cases of very large irreducible hernia the sudden return of considerable masses of intestine which have lain for years in the hernial sac so increases the intra-abdominal tension as to disturb the heart's action and frequently leads to recurrence locally or elsewhere. Operation though very desirable owing to the great risk of strangulation incurred by the patient is often followed by bad results, unless the patient has previously been strictly dieted and given a firm abdominal support in order to reduce gradually the size of the protrusion. Obviously in those cases where the hernia is secondary to such conditions as an enlarged prostrate or a stricture it is essential to treat the primary condition first.

As to the best age at which to operate babies and children can almost always be cured and healthy young adults do equally well since the operation consists in correcting a congenital abnormality Older patients, especially those with direct herniæ are more prone to recurrence

Operative Treatment The operation for the radical cure of an inguinal hernia has been gradually evolved and is based on the recognition of two general principles *viz* (*a*) It is essential to remove the sac completely or otherwise so to deal with it as to make it harmless, (*b*) the defect in the abdominal wall must be closed in such a manner as to leave sufficient room for the due protection of the spermatic cord. In young people the sac is the important element and the muscular defect of less importance as age progresses the lesion in the wall requires more careful attention until in old people with small direct herniæ the sac may often be neglected and attention given solely to the abdominal parietes. It must also be noted that in young people the upper part of the canal is the chief area of weakness, but in elderly people this shifts to the lower part of the canal.

Many different operations have been described and in efficient hands

they are all capable of giving good results It must here suffice to describe carefully one typical operation Bassini s, and then to note some of the modifications which have been suggested

Bassini's Operation This may be described in the following stages (*a*) The pubic region having been previously shaved and thoroughly cleaned, an incision is made over the inguinal canal and cord its centre being a little above the superficial inguinal ring. This is deepened until the cord is reached the superficial external pudendal artery necessarily divided *en route* the pillars of the ring are clearly defined and the external oblique aponeurosis slit up in the direction of the cord (*b*) The sac has now to be identified If the hernia is one of long standing or contains adherent omentum or intestine, it is easily recognized but if it is thin empty and of recent formation and especially in the case of a bubonocele its identification may be a matter of some difficulty The cremaster and other coverings of the cord are incised longitudinally and the sac looked for and isolated with as little handling and disturbance of the parts as possible Enlarged veins may be removed, as also fatty protrusions from the subperitoneal tissue It is sometimes necessary to lift up the structures of the cord in order to define the sac, which is often recognized by the white convex border of the fundus. (*c*) If the sac is empty it is freed from its connection with the structures of the cord without opening it and isolated as far as or beyond the deep inguinal ring, as indicated by a collar of fatty subperitoneal tissue surrounding the neck. If the hernia is irreducible the sac is laid open, its contents freed from adhesions and the intestine returned into the abdomen while omental tissue is removed and the stump replaced. Adhesions are carefully divided either by the finger or between ligatures if the gut is closely adherent to the sac, it may be necessary to leave a small portion of this attached to the intestine which is then returned. Omentum, whether adherent or not, should be removed as the elongated fringes are very liable to contract adhesions to the abdominal parieties which subsequently produce trouble. In removing omentum, it is unwise to encircle a large mass with a single ligature, as it is then more difficult to replace, the vessels are less securely commanded and a pocket or pucker may be produced, possibly leading to internal strangulation at a later date. Small portions, including one or more of the larger vessels, should be taken up one after another and tied separately with advantage at different levels, so as to assist in the subsequent return of the stump The protruded mass is then cut away below the ligatures and the stump replaced, after seeing that no bleeding point remains unsecured. The sac, being now emptied, is isolated as far as the deep ring. (*d*) The neck, drawn firmly down, is transfixed as high as possible and ligatured with catgut or thread, so that when the sac is cut away below the ligature the stump retracts well above the deep ring and presents a flush surface towards the intestines. (*e*) The opening in the abdominal parietes is closed by a row of sutures passing through the arched fibres of the internal oblique and transversalis muscles or through the conjoined tendon on the inner side and through the inguinal ligament on the outer the stitches being all placed *behind* the cord. To effect this, the cord is drawn out of the wound and held aside by a retractor (Fig. 44 16) while the divided margins of the external oblique aponeurosis are grasped by pressure forceps. Gentle traction on the lower pair enables the deepest portion of the inguinal ligament to be defined and seen. The stitches must

secure a good hold of the tissues, but should not include the external oblique aponeurosis and when dealing with the inguinal ligament the proximity of the iliac vessels must not be forgotten. Either interrupted or looped mattress sutures may be used, but if the latter they must not be tied too tightly as they may strangle the portions of tissue included in their grasp and cause necrosis. The opening in the abdominal parietes is in this way secured as far down as the pubic spine, but sufficient room must be left at the upper end for the passage of the cord It is desirable to introduce a stitch above the cord in order to close a gap where recurrence is not uncommon When the necessary stitches have been introduced and tightened the cord is replaced, and the divided portions of the external oblique are sutured together over it, as also the deep fascia (*f*) The wound in the skin is closed and usually no drainage-tube is needed.

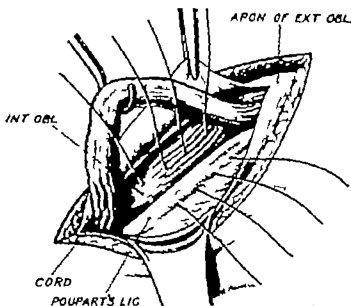


FIG. 44 16. BASSINI'S OPERATION FOR RADICAL CURE OF LEFT INGUINAL HERNIA.

There are obvious disadvantages in this operation The abdominal musculature of the normal adult contracts when he embarks on any act of straining and the curved fibres of the conjoined tendon which are muscular in a large part of it, extend, straighten out to obliterate the inguinal canal and prevent the descent of the congenital sac of peritoneum If an endeavour is made to obliterate the inguinal canal by tying tightly the sutures between the conjoined tendon and the deep aspect of the inguinal ligament, the blood supply of the musculature of the former is interfered with and fibrosis results, so that the musculature is weaker after the operation than before. If the sutures are tied loosely they soon become absorbed and the slight inflammatory reaction that occurs is insufficient to obliterate the canal, so that a recurrence becomes possible. The fact that the operation is successful in some 90 per cent. of cases is probably due as much to complete removal of the sac as to the subsequent repair of the inguinal canal.

A great many variations of the above operation are in use and a wide variety of non-absorbable sutures such as silk, linen thread terylene and

fine steel wire are recommended by different surgeons Relieving incisions can be made in the rectus sheath to allow the tissues to slide downward behind the cord or flaps of rectus sheath may be hinged outward for the same purpose. In difficult herniæ the use of autogenous material and especially the patient s own fascia offers a useful technique for closing large defects a technique introduced by Gallie of Toronto

Gallie s Operation The essential feature of this procedure is the obliteration of the canal by a fascial graft sewn between the deep aspect of the inguinal ligament and the internal oblique and conjoined tendon The fascial strip used may be dissected off the aponeurosis of the external oblique or preferably removed from the fascia lata of the thigh, as from this source a larger strip may be obtained. It was originally necessary to make a long incision for the purpose of obtaining a fascial strip but a very adequate segment may be removed subcutaneously with the aid of a fascial stripper A 2 inch (5 cm) transverse incision is made over the lower part of the fascia lata in the thigh and a piece 1 inch (2 5 cm) wide is dissected up for a little way This free end is then threaded between the blades of the fascial stripper which latter is then negotiated subcutaneously up the thigh to its full extent of about 8 inches (20 cm) A tenotomy knife is then used to divide the strip of fascia through the skin at its upper extremity

In using the strip it is best first to divide it longitudinally to 2 5 cm (1 inch) from one extremity At this point a catgut suture is inserted to prevent the split running up further A small longitudinal incision is than made into the undivided extremity and a suture similarly placed at either end. The fascial strip is then ready for use

For threading the strips between the conjoined tendon and the inguinal ligament the ends may be attached to Gallie s needles, or else they may be drawn through with the aid of a Miles fascia forceps. In either case the two free ends are drawn through the fascia over the pubic bone and are then threaded through the hole in the wide extremity A firm fixation for the fascial strip is thus obtained The two ends of the strip are then laced criss-cross, underneath the end which is retracted well out of the way between the conjoined tendon and the deep aspect of the inguinal ligament as far as the deep inguinal ring, where the ends are fixed with a catgut suture. It is essential that no tension be placed on the fascial strip else the disadvantage mentioned in connection with Bassini s operation will apply in this case. It is a good plan to suture the loops of the fascial strip periodically so that there is no danger of their being drawn tight (Fig. 44 17)

Repair operations such as Halsted s, in which the cord is placed subcutaneously are occasionally of value in very old patients.

In cases of simple herniotomy it is sufficient to keep the patient in bed for a few days during which time he is encouraged to do abdominal exercises to keep his muscles from undergoing atrophy For at least three months after the operation no heavy exercise or heavy labouring must be undertaken.

Direct Inguinal Hernia. The treatment is modified by the fact that the condition usually occurs in elderly men In many it is wise to order a double truss and avoid operation but in some operation is permissible. The prognosis is never so good as in the oblique variety (*a*) because it occurs in older subjects, and is often predisposed to by chronic obesity cough or difficulty in micturition, (*b*) because the chief weakness is at the lower and not the upper end of the canal, hence the deep ring lies almost directly

behind the opening in the external oblique. In these cases experience has taught that the best plan to adopt is to displace the cord entirely bringing it out through the muscles opposite the deep inguinal ring and closing up the rest of the canal completely as in a woman, with the aid of a fascial graft. The more superficial position of the cord does not seem to affect it injuriously especially if a good pad of fat is sutured around it

Recurrence after Operation. This is less common than formerly and in experienced hands less than 10 per cent recur and that rarely after the first twelve months. The skill of the operator a meticulous technique and great attention to detail are more important than the type of operation chosen. Recurrence is often due to a want of appreciation of the necessity for isolating the sac as far as possible since otherwise the infundibuliform opening

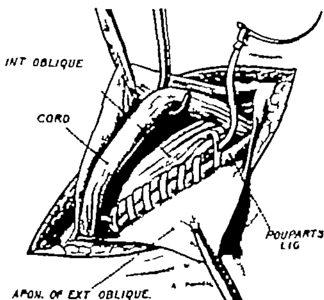


FIG. 44 17 RADICAL CURE OF LEFT INGUINAL HERNIA, USING STRIPS OF FASCIA LATA.

at the top of the closed peritoneal canal is certain to persist. Another cause of recurrence is pyogenic contamination of the wound If the deep stitches are not involved, no great harm is done but whenever they have to be removed or come away recurrence is probable. Relapses are also due to splitting or tearing of the tendinous structures around, either by the mere passage of the needle or by the traction induced by tightening the sutures indeed, it is probably from this cause that a hernia originally oblique is after operation followed by one that is direct.

Whenever it appears likely that recurrence may occur a light truss should be ordered If however a hernia has developed a second operation may be performed if warranted by the condition of the abdominal parietes.

Treatment by Injection. This form of treatment is now only of historical interest being used as long ago as 1832 by the American George Heaton With the advent of Listerian surgery it was largely abandoned, but of recent years it has occasionally been revived. It consists in the injection of a sclerosing fluid into the inguinal canal about the sac, a solution containing zinc sulphate and phenol being generally used A series of twenty or thirty

weekly injections are necessary and throughout the course of treatment the patient must be instructed to wear a well fitting truss night and day

Femoral Hernia

Anatomy A femoral hernia is one which travelling down the femoral canal presents at the inner and upper part of the thigh through the saphenous opening It occurs most commonly in women on account of the greater expansion of the iliac crests allowing increased space beneath the inguinal ligament especially in those who have borne children During parturition the inguinal regions are in a measure protected hence inguinal hernia is rarely caused in this way In young people, however it is more common in the male sex.

The femoral canal constitutes the inner compartment of the femoral sheath a space usually occupied by fatty cellular tissue lymphatic vessels and often a lymphatic node It is about ¾ inch (2 cm.) in length anteriorly and 1¼ inches (3 cm) along its posterior wall it is closed above by a thickened portion of the subserous cellular tissue known as the septum crurum and its lower end is formed by the saphenous opening, and closed by the cribriform fascia Hence a femoral hernia, as it passes downwards, receives the following coverings (*a*) peritoneum (*b*) subserous cellular tissue including the septum crurum a layer sometimes known as the fascia propria, and occasionally represented by a thick fatty envelope (*c*) the anterior layer of the femoral sheath derived from the fascia transversalis, (*d*) cribriform fascia (*e*) subcutaneous tissue, (*f*) skin. In its passage through the canal it is situated immediately medial to the femoral vein and pressure upon this may produce œdema of the leg, while Gimbernat s ligament (the pectineal part of the inguinal ligament) lies to the inner side. The spermatic cord or round ligament is placed just above and medial to it, but on a superficial plane while the epigastric artery is not very far from the outer side of the neck. Occasionally the obturator artery arises from this latter vessel it may pass to the inner side of the neck of the sac along the border of Gimbernat s ligament, but more commonly runs between the neck and the femoral vein *When once it has emerged from the saphenous opening, a femoral hernia* usually travels upwards and outwards along the inguinal ligament towards the anterior superior iliac spine, being guided by the attachment of the deep layer of the superficial fascia when of large size, it may extend considerably above the level of the inguinal ligament. Femoral herniæ are less likely to contain omentum than the inguinal variety a portion of the ileum is most often present, but occasionally the ovary or Fallopian tube may be found in the sac.

Rarely the hernia passes in front of the femoral vessels or to the lateral side In other cases it may pass through the ligament of Gimbernat, and occasionally it burrows through a deficiency in the pectineus muscle.

Physical Signs These are very characteristic. A rounded *swelling* with an expansile impulse on coughing, more or less reducible, forms on the inner side of the thigh its neck or aperture of communication with the abdomen lying to the medial side of the *femoral vessels* and to the lateral side of the pubic *spine, which can always be easily felt (Fig 44 18)* There is usually little difficulty in making a diagnosis, although occasionally some care is needed. (*a*) An *inguinal hernia* is recognized by the fact that its neck occupies the inguinal canal, the saphenous opening being *free* while it is also above and medial to the pubic spine, and above the inguinal ligament

at its point of exit it tends to pass downwards into the scrotum, or in females into the labium Femoral hernia, on the other hand, usually (but not invariably) occurs in women over twenty five years of age the inguinal canal is free, while the neck is in the situation of the crural canal below and *external to the pubic spine and below the inguinal ligament* moreover it travels upwards and outwards, the labium being unaffected. (*b*) An *enlarged lymphatic node* over the saphenous opening may simulate this condition *very closely* but the absence of an expansile impulse on coughing and of the usual hernial signs is generally sufficient to distinguish it when however the hernia is purely omental and irreducible the impulse is so



FIG. 44 18. BILATERAL FEMORAL HERNIÆ.

slightly marked that correct diagnosis in a stout woman is often difficult without an exploratory incision. (*c*) A small *lipoma* in the canal somewhat resembles a hernia, but the limitation of the tumour its greater mobility and the absence of an impulse on coughing, should suffice to prevent a mistake. (*d*) A *psoas abscess* pointing at the saphenous opening resembles a hernia *in the existence of a reducible swelling* with an expansile impulse on coughing It is distinguished from it by the fact that there is no gurgle on reduction that the abscess, as it passes under the inguinal ligament lies to the outer side of and behind the vessels that a tense swelling occupies the iliac fossa, between which and the swelling presenting at the saphenous opening fluctuation can be readily detected the characteristic signs of spinal caries are also usually present. (*e*) In *varix of the internal saphena* a pouch or ampulla developing close to its upper end may be mistaken for a femoral hernia on account of the marked expansile impulse on coughing, but the swelling disappears on assuming the recumbent position The impulse however *is of a different character from that of a hernia the blood* can be felt to be driven past the examining finger with a thrill instead of there being merely an expansile bulge Moreover if the swelling is reduced by recumbency and a finger is then placed over the upper end of the femoral canal so as to occlude it, the dilated vein fills up again from below on assuming the erect position the hernia does not descend *Finally* other signs of varix are usually present in the limb

Treatment When reducible and of small size a femoral hernia may on rare occasions be treated by the use of a *truss* similar in nature to that used for an inguinal hernia except that the pad extends somewhat lower It is not, however a desirable practice on account of the difficulty in controlling the hernia and on account of the liability to strangulation

Operative Treatment Radical cure is always desirable when practicable and ought to form part of all operations for the relief of strangulation The complete removal of the sac is an essential part of the procedure and the blocking of the entrance to the femoral canal or its obliteration by approximating its anterior and posterior walls is the only sure preventive of recurrence.

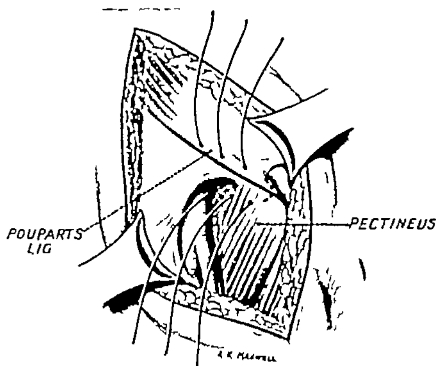


FIG. 44 19 THE RADICAL CURE FOR RIGHT FEMORAL HERNIA.

Three chief methods of approach are possible one from below in the groin, the others from above.

(1) In the *operation from below* the sac is exposed by a vertical incision along the course of the femoral canal cleared completely of its fatty covering, which is often thick and abundant, emptied of its contents by reduction, and then cut away after transfixing and tying the neck. Some surgeons, however retain the sac, pushing it back into the abdomen, and using it as a pad across the upper opening of the canal. The deep ring is then closed by one of the following methods (*a*) In many of the simpler cases it will suffice to introduce three sutures through the inner end of the inguinal ligament (Fig. 44 19) and deeply through the horizontal fibres of Cooper s ligament, which lies in close apposition to the horizontal ramus of the pubis. There are few cases where this manœuvre, if effectively carried out, is not sufficient to close the canal but for this purpose the hernia needle must be carried down to the bone and not merely through the fascia over the pectineus. (*b*) In a few cases where the opening is larger it may be desirable

to approximate the inguinal ligament to the horizontal ramus by some other method and for this purpose Roux advised the use of a ∩-shaped metal staple which traversed the ligament, the free ends being driven into the bone. This plan appears to us undesirable since the staple occasionally works loose and then the proximity of the femoral vein makes it an unwelcome neighbour. (c) A good substitute for this plan was practised by Nicoll of Glasgow who drilled the horizontal ramus from below upwards in two spots and passed a mattress suture through the inguinal ligament and bone, tying below; the ligament is thus safely approximated to the inner and upper aspect of the pubis.

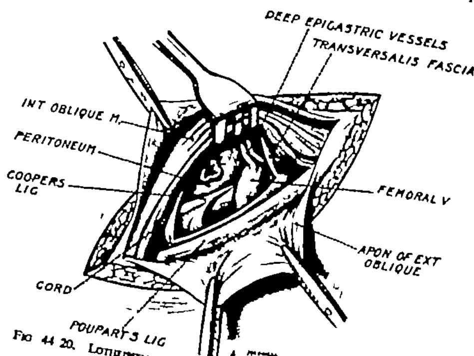


FIG 44 20. LOTHEISSEN'S OPERATION FOR LEFT FEMORAL HERNIA.

The general results of this operation have proved unsatisfactory in the hands of most surgeons a large percentage of cases recurring (10 to 20 per cent). This is probably due to three causes ligaturing the sac below the femoral canal without sufficient traction insufficient clearance of the neck of the sac, some of the fatty envelope which descends with the sac remaining and preventing perfect occlusion of the canal and inefficient closure of the canal.

(2) To obviate these defects an *inguinal operation* (Lotheissen's operation) was introduced to deal more effectively with the neck of the sac and to avoid the dangers associated with the close proximity of the femoral vein. An incision is made as for inguinal hernia but is carried a little further inwards over the pubes. The inguinal canal is opened by incising the superficial inguinal ring and carrying the incision up and out. The internal oblique and transversalis, together with the cord or the round ligament, are drawn aside by one retractor while the external oblique is retracted outwards by another. The floor of the canal can now be seen and is carefully explored

so as to bare the subperitoneal fat covering the neck of the sac which is defined If the hernial contents are reducible the sac can often be pulled up without trouble into the wound and there ligatured and excised, but if there is difficulty with this, the sac must be exposed below the inguinal ligament by pulling down the lower flap of skin It can then be cleared of its fatty envelope opened and its contents dealt with by open reduction or removal so as to enable the sac to be pushed up through the crural canal into the upper part of the wound. There its neck is cleared transfixed and ligatured and the fundus cut away The femoral ring is now clearly visible and can be controlled by sutures passed between Cooper s ligament behind and the inguinal ligament in front, under the guidance of the eye. It is this together with the complete removal of the sac, that constitutes the special merit of this procedure there is no groping in the dark the surgeon can see what he is doing (Fig. 44 20) In cases of difficulty where considerable tension is likely to fall upon the stitches, it may be desirable to detach a flap of the anterior sheath of the rectus muscle and secure it across the upper opening of the femoral canal by stitching it to the under-side of the inguinal ligament as far out as the femoral vessels, or better still to use a fascial strip obtained from the thigh Careful closure of the inguinal canal completes the operation which has been followed by good results Where any weakness of the inguinal canal exists this can be treated at the same time by a Bassini repair

(3) The Cheatle or Henry operation offers a good anatomical exposure from above without disturbing the contents of the inguinal canal. A low mid-line incision is used giving access to either or both sides after retraction of the rectus abdominus muscle and incision of the transversalis fascia. The sac is emptied and closed and the gap repaired by suturing the conjoined tendon to Cooper s ligament.

Umbilical Hernia

Three forms of umbilical hernia are described.

Exomphalos or Omphalocele. This is a very rare condition, due to imperfect closure of the abdominal walls, as a result of which part of the intestine is found at birth in a cavity at the base of the umbilical cord, which



FIG. 44 21 EXOMPHALOS.

is bulbous and enlarged (Fig. 44 21). If left untreated until the cord has separated the peritoneal cavity may be laid open.

Treatment. Operation should be carried out immediately after birth. If possible the abdominal wall is closed in layers after excising the sac. If this is not possible temporary cover is provided by suturing the skin over the intestines. Six months later the abdominal wall is reconstructed.

Umbilical Hernia of Infants. This condition which used to be called "starting of the navel" is due to weakness of the umbilical cicatrix, which yields before the intra abdominal pressure. Its occurrence may be determined by chronic constipation, necessitating continual straining in order to evacuate the bowels. The condition rarely persists till adult life.

Treatment. This consists in regulating the bowels, while the local condition is dealt with by strapping the abdominal wall in such a way as to tuck the umbilical cicatrix inwards; no pad is required. An alternative method is a light rubber belt with pad over the navel. Umbilical hernia in babies almost invariably closes spontaneously as is well seen in African babies in whom the condition is extremely common under 3 years of age.

Umbilical Hernia of Adults. This is usually due to a protrusion of omentum or intestine through an opening in the linea alba, either immediately above or below the umbilicus, the former being the more common. A more frequent variety is that seen in women who have borne children, being sometimes due to stretching or actual rupture of the linea alba and separation of the recti muscles. A peritoneal sac is present, but in old-standing cases it is extremely attenuated and so adherent to surrounding parts as to be unrecognizable, while the contents may be matted together in an almost inextricable confusion. In such circumstances obstruction is very liable to ensue and if combined as is usual with a subacute form of inflammation it may even proceed to strangulation. The skin over the tumour becomes stretched, atrophic and may ulcerate so that perforation threatens. The hernia is often lobulated in outline and a considerable deposit of fat sometimes surrounds it.

Treatment. Retentive apparatus is of little value and certainly has no curative effect when the hernia is irreducible neither does it hinder it from increasing in size. Possibly in the early stages of a small reducible hernia a closely fitting elastic belt or bandage with a suitable pad over the opening may be of some use, but the pressure required to make it effective is often a source of great discomfort.

Operative treatment is never easy as the patients are not favourable subjects often fat and unhealthy and usually the subjects of chronic bronchitis. A preliminary course of treatment is always desirable so as to unload the bowel completely and to reduce the amount of fat; hygienic and dietetic measures with this end in view must be instituted. The character of the operation will vary according to whether the hernia is more or less limited to the umbilical area or whether in addition the linea alba is generally weak and relaxed. In the former removal of the sac and approximation of the edges of the opening may be adopted; in the latter it may be well to work through a longitudinal and not a transverse incision so as to be able to deal with the relaxed linea alba at the same time. In both cases the same principle is adopted that of overlapping or imbricating the edges so as to gain surface-to-surface union, for the margins of the hernial opening are so unhealthy and fibrous that edge-to-edge union could never be expected.

Mayo's Operation Transverse crescentic incisions are made both above and below the hernia so as to encircle it. The sac is carefully defined and cleared of fat as also the aponeurosis of the recti muscles for some way around (Fig 44 22) The aponeurosis is then divided close to the neck by transverse incisions and the sac opened The contents are turned out and

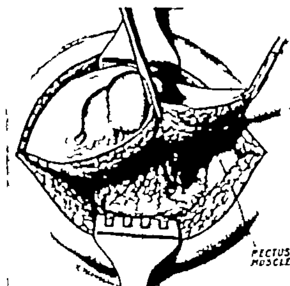


FIG. 44 22. MAYO'S OPERATION FOR UMBILICAL HERNIA.
The incision and removal of fat from the abdominal wall.

examined Omentum is almost always present and often adherent to intestine, sac and margins of the opening. Generally speaking, most of the omentum thus found is removed it usually constitutes a thick fibro-fatty mass, tangled and adherent and useless as omentum Special care is directed to the margins of the opening, which must be completely cleared. The intestine, both small

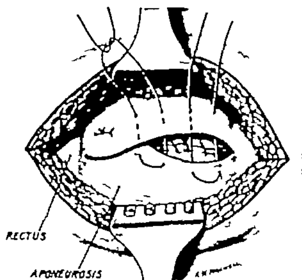


FIG 44 23 MAYO'S OPERATION FOR UMBILICAL HERNIA.
The peritoneal layer is closed and mattress sutures have been inserted to produce horizontal over lapping of the rectus sheath.

and large, is generally reduced without difficulty when the omentum is set free. The sac, the adherent tags of omentum within it and the overlying skin are then cut away completely and great care is taken to secure hæmostasis of the cut edges. The opening is now limited by two peritoneo-aponeurotic flaps, above and below respectively and is closed by overlapping

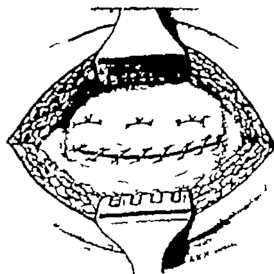


FIG. 44 24 MAYO'S OPERATION FOR UMBILICAL HERNIA.
The mattress sutures are tied and the overlap secured with additional sutures.

the upper of these over the lower by means of mattress sutures introduced through the margins of the lower and passed under and through the upper from within outwards as far up as possible (Figs 44 23 and 24). The upper flap is then stitched down over the lower which it usually overlaps to the extent of nearly 2 inches (5 cm.). Non-absorbable sutures or chromic catgut is used. The subcutaneous tissues are brought together by buried stitches provision is made for drainage and the skin wound is closed.

Ventral Hernia

This term is used in describing any protrusion occurring at some spot in the anterior abdominal wall other than those already mentioned. Several forms may be met with

Epigastric Hernia. This consists of a protrusion of subserous fatty tissue through a congenital or acquired opening in the linea alba lineæ semilunares, or lineæ transversæ, especially at the junction of the last with the former. They are more common above than below the umbilicus and if as not unfrequently happens the fatty tissue proliferates a localized tumour resembling a lipoma is produced which goes by the name of a *fatty hernia of the linea alba*. A portion of the peritoneum is drawn through the opening into the centre of these masses after they have persisted for some little time so that a true hernia is produced. Considerable pain and abdominal disturbance (vomiting, colic, etc.) accompany almost every movement of the body being caused partly by the traction on the peritoneum partly by the constriction of the neck of the sac against the sharp edges of the small opening. Treatment consists in the removal of the projecting mass, care being taken not to include any viscera in the suture with which the base

is surrounded. The stump is pushed back into the abdomen and the opening closed by interrupted sutures.

Incisional Hernia. After operations involving the division of the abdominal parietes, a hernia may be caused by the yielding of the cicatrix, especially if the wound suppurates and the deep stitches come away or if an opening is left for the purpose of draining an abscess (Fig. 44 25) Treatment of such cases is conducted along the lines suggested for that of an umbilical hernia freeing the margins of the gap from adhesions and replacing or removing the contents the sac is then excised and perhaps the overlying



FIG. 44 25 INCISIONAL HERNIA FOLLOWING OPERATION FOR ACUTE APPENDICITIS.

fat and skin the opening is closed by overlapping the walls, or by implanting a fascial graft, or by deep fascial stitches. Considerable skill and judgment are required if this procedure is to be effective but good results may be anticipated. Recently sheets of tantalum gauze or nylon mesh have been used to close such defects with some success

Divarication of the Recti. In women who have borne children the linea alba often stretches and yields, allowing considerable separation of the recti muscles for almost their whole length and this apart from any umbilical hernia. If placed in the recumbent posture, and told to raise the head and shoulders from the bed without using the elbows for support, the linea protrudes as a longitudinal ridge of considerable breadth Much discomfort and dyspepsia arises from this cause, owing to the inefficient support given to the intestines. A firm abdominal belt may be used as a palliative measure, but operation is possible. The thinned linea alba is split down the middle from top to bottom if need be on one side—say the right—it, together with the neighbouring rectus muscle, is separated from the subcutaneous tissues and tucked under the rectus on the left side its free end being secured by a row of mattress sutures passing through its edge and the left linea semilunaris, and being tied superficially The left free edge is subsequently secured to the right linea semilunaris by a row of stitches. Redundant fat

and skin are removed and the wound closed by sutures. In this way the abdominal wall is drawn together like a double-breasted coat. An alternative plan, which is now rarely practised, is to detach the recti muscles from their insertions, cross them over one another and re-insert them.

Lumbar Hernia

A lumbar hernia is a condition of considerable rarity in which the abdominal viscera protrude by the side of the sacrospinalis between the latissimus dorsi and the external oblique, in the space known as Petit's triangle. It is perhaps seen most frequently after operations upon the kidney where suppuration has occurred, and the deep stitches have had to be removed. The ordinary signs of hernia are present and with a little care the condition is readily distinguished from a lumbar abscess.

Treatment. This is conducted along the same lines as for a ventral hernia.

Diaphragmatic Hernia

Herniation through the diaphragm may be congenital or acquired, the former often producing symptoms in the newborn. The latter may be traumatic in origin or associated with an abnormal œsophageal hiatus.

Congenital Diaphragmatic Hernia. The diaphragm develops from five parts: a central, two ventral and two dorsal. Between the dorsal and central parts, thorax and abdomen communicate by means of the pleuro-peritoneal hiatus which normally closes before birth. If the hiatus persists it is called the foramen of Bochdalek and herniation of abdominal contents through it into the chest may occur. It commonly occurs on the left side.

Signs and Symptoms. In a typical case the baby appears cyanosed immediately after birth and there are signs of air hunger. The apex beat is in the right mid-axillary line and bowel sounds will be heard over the left chest. A skiagram shows the mediastinum pushed over to the right with bowel filling the left thorax.



FIG. 44 26. DIAPHRAGMATIC HERNIA. MOST OF THE STOMACH IS IN THE LEFT PLEURAL CAVITY

Treatment The baby is nursed in an oxygen tent and taken to the operating theatre as quickly as possible Under intratracheal anæsthesia an incision is made either over the left chest or the abdomen The bowel is replaced in the peritoneal cavity and the opening in the diaphragm closed by drawing together the edges, after crushing the phrenic nerve

Herniation through the foramen of Morgagni via which the bowel passes up behind the xiphisternum is a rarity the symptoms are those of intermittent subacute bowel obstruction and the diagnosis is made radiographically

Traumatic Diaphragmatic Hernia. This is almost always due to stab or gun-shot wounds. The abdominal organs may prolapse into the chest at the time of wounding or more commonly this occurs many years after the original trauma. There may be respiratory or cardiac embarrassment especially on exercise or the bowel within the chest may strangulate Surgical treatment may be carried out by approaching the diaphragm from above or below the former more often giving the best access. Bowel is reduced and the opening closed if large it may be darned with strips of fascia lata

Hiatus Hernia. This occurs commonly in obese women after fifty years of age who suffer from flatulent dyspepsia and regurgitate acid when they stoop down A sac of peritoneum protrudes through the œsophageal hiatus and produces a *sliding hernia* when stomach and œsophagus rise together into the chest or a *rolling hernia* when a knuckle of stomach insinuates itself beside the lower œsophagus.

Acid and pepsin pass through the incompetent œsophagogastric sphincter to produce reflux œsophagitis. Loss of blood in the vomit may lead to anæmia ulceration and fibrosis to stricture of the lower œsophagus. There is often associated with this condition, disease of the gall-bladder and diverticulosis of the colon

Treatment When the symptoms are not severe, this is usually best carried out on conservative lines. The patient should avoid stooping, sleep with extra pillows or put blocks under the head of the bed and take an antacid powder to relieve the œsophagitis. When stricture of the œsophagus occurs, simple bouginage may suffice to give an adequate lumen Crushing the left phrenic nerve may relieve the symptoms. When the symptoms are really severe, operative intervention is called for but the form it should take has still not been satisfactorily decided Partial gastrectomy by relieving acid secretion and pyloroplasty by relieving any gastric hold up may succeed. If the lower œsophagus is the site of a stricture it has to be removed together with the stomach and continuity restored by a Roux-en-Y anastomosis of ejunum to œsophagus

Obturator Hernia

An obturator hernia consists in a protrusion of intestine through the upper part of the obturator foramen and has usually been observed in elderly females. Multiple pregnancy is an important factor in its causation owing to the relaxed condition of the peritoneum produced It is not often recognized in the living, except when strangulated and even then it is more likely to be discovered from the abdominal aspect during a laparotomy for acute obstruction than diagnosed apart from operation In a few cases, however it has been noted that, in addition to the general signs of strangulation, there was a sense of deep resistance and of fullness close to the origin of the adductor muscles and that pain was referred down the obturator nerve to the inner

side of the knee (Fig. 44 27). Rectal or vaginal examination may throw some light on the nature of the case (Fig. 44 28).

Treatment This is generally an operation to deal with strangulation and exposure is by means of an abdominal incision with the patient in the Trendelenburg position over the hernial protrusion or by a combination of

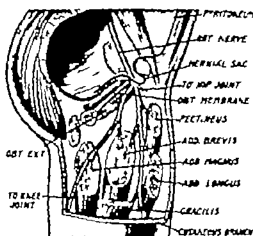


Fig. 44 27 Relation of Obturator Nerve to the Obturator Canal.

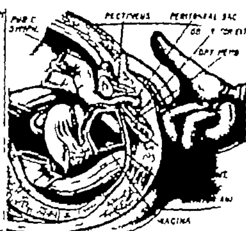


Fig. 44 28. Obturator Hernia. Sac felt on Vaginal Examination.

these routes In those rare cases, where strangulation is not present and a correct diagnosis has been made the sac may be exposed by an inguinal incision with retraction of the aponeurosis of the external oblique and the cord upwards. The sac when found should be opened and the strangulation relieved by stretching digitally or if this fails, cutting upwards the constricting

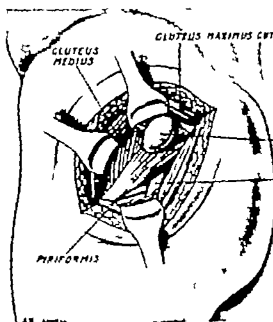


Fig. 44 29 Sciatic Hernia. Sac exposed above the Piriformis Muscle.

fibrous ring, the obturator vessels being usually situated below the neck of the sac. If found during a laparotomy for obstruction the same precautions must be taken as for a Richter's hernia. It is possible to close the abdominal opening by a peritoneal purse-string suture introduced from above, if the patient is in the Trendelenburg position.

Other Rare Herniæ. *Pudic pudendal vaginal and sciatic herniæ* (Fig. 44 29) have been described but are so uncommon that they need no special mention except to add that they usually are discovered when they produce obstruction.

Complications of Herniæ

An irreducible hernia is one form in which the contents can no longer be returned to the abdominal cavity. If the contents remain viable it is described as an incarcerated hernia; if the blood supply to the contents is cut off it is said to be strangulated.

Incarcerated Hernia. This is usually due to adhesions between the contents of the sac or between the contents and the wall of the hernia, constriction of the neck of the sac, deposition of fat or distension of bowel within the hernia.

The local signs and symptoms are those of discomfort, a dragging pain, an irreducible mass and occasionally dyspepsia.

Treatment. Operation is always indicated for irreducible herniæ since a truss will only aggravate the condition. If the patient is overweight or physically unfit for surgery, time can be taken to improve his general condition and if necessary reduce his weight. At operation, bowel is returned to the abdomen after dividing any adhesions and the fat-laden omentum is excised after carefully sewing the cut edge, piecemeal with ligatures so that no bleeding point slips back into the general peritoneal cavity.

Inflammation is a rare complication of an obstructed hernia and is usually due either to an inflamed appendix being contained within the sac or to the injudicious use of an ill fitting truss. Treatment is immediate operation combined with a course of suitable antibiotics.

On the rare occasions when it is impossible to operate on an irreducible hernia and in babies or children awaiting operation, *taxis* may be attempted. Taxis is the term used for the manipulation by means of which a hernia is reduced. The patient is laid on a couch with the legs raised and thighs slightly flexed. An ice bag is placed over the swelling and after half an hour gentle pressure is made over the hernia in an attempt to milk the contents back into the abdomen. Gentleness and care are imperative; moreover if the manœuvre is unsuccessful no further attempt should be made.

Strangulated Hernia. Strangulation is the most serious complication that can befall a hernia for it connotes not only obstruction of the contents but also obstruction of their blood supply. Since most herniæ contain gut, intestinal obstruction and gangrene result. Interference with the passage of fæces is not an essential in this condition, since omentum alone may be involved, or the intestine, if present, may only have a portion of its lumen constricted, as in the form known as *Richter's hernia* (Fig. 44 31), while in *Littré's hernia* a diverticulum is similarly affected (Fig. 44 30).

Two chief varieties of strangulation are described: those occurring within the abdomen, and those which are extra-abdominal; it is only the latter to which we shall now direct attention.

External Strangulated Hernia. This arises in one of two ways (*a*) The hernia becomes strangled immediately after its formation this is most frequently seen in children or adolescents, the hernia being then of the congenital type and having a long narrow sac. (*b*) In adults it more frequently results from extrusion of an additional amount of the abdominal contents into the sac, as the outcome of some sudden violent effort. This condition usually occurs in old-standing herniæ the neck of the sac having previously become thickened and contracted either by the pressure of a truss or the irritation of the protruded viscera. The former of these two conditions is generally acute in character the latter more often subacute

The site of the constriction is either at the neck of the sac or in the dense tissues external to it, but occasionally it exists elsewhere Most frequently

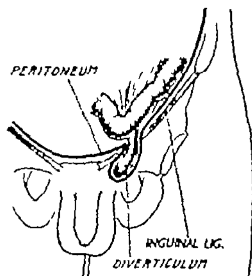


FIG. 44 30. LITTRÉ'S HERNIA.

the active agent in the strangulation is the thickened sac wall itself but in femoral and umbilical herniæ structures outside the sac, such as the pectineal part of the inguinal ligament or the linea alba may be the actual cause of the constriction, while it may also be produced by the passage of a coil of intestine under a tight adhesion or through a slit or aperture in the omentum contained in the sac. In those herniæ which become strangulated immediately after their protrusion, the constricting cause is invariably the resistance of the tissues surrounding the opening in the abdominal parietes

Pathology The effects of strangulation vary somewhat with the tightness of the constriction The circulation is seldom arrested entirely at the onset of the symptoms but the pressure first affects the veins and later by the congestion and exudation thus produced, the flow in the arteries. Hence the constricted tissues are congested to begin with and then as a result of the deficient supply of arterial blood gangrene ensues with or without an intervening period of inflammation

When a portion of intestine is strangulated it first becomes of a dusky red chocolate or claret colour owing to vascular congestion It is thickened and stiff from exudation into its walls and distended by the formation of gas within its lumen owing to the arrest of peristalsis and the putrefaction

of its contents. The surface for a time remains smooth and shiny but as the exudation into the sac increases the endothelium is shed Occasionally some of the superficial capillaries rupture giving rise to ecchymoses and in rare instances, possibly as the result of injudicious taxis the sac is filled with clotted blood the intestine in consequence becoming lax and yellowish-grey in colour When the strangulation is relieved in this early stage, the bowel soon regains its former healthy appearance If inflammation occurs, the surface becomes rough from the deposit of lymph losing its shiny and polished aspect Gangrene results partly from the prolonged stagnation of blood and partly from the invasion of the intestinal wall by *Esch coli* and anaerobic inhabitants of the gut which, as soon as the vitality of the intestinal wall is sufficiently impaired migrate through it As soon as it is established the intestine turns an ashy grey or black colour usually at one or more spots which gradually spread and become soft and offensive Gangrene is much more common in femoral and umbilical forms of hernia than in inguinal It is generally developed in two or three days but occasionally may supervene in less than twenty four hours from the onset of the strangulation It is more often seen in the small herniæ of recent origin than in large old standing ones. At the point of strangulation the gut is liable to ulceration or gangrene, which may subsequently result in perforation adhesions may however form between it and the neck of the sac, thus preventing contamination of the general peritoneal cavity The intestine above the site of strangulation becomes paralysed, peristalsis is arrested even in a Richter s hernia Fæcal material accumulating and undergoing decomposition gives rise to enteritis, occasionally to stercoral ulcers, which may perforate and cause general peritonitis this, however is not very common in external strangulation since the small intestine is usually involved and solid fæces are absent.

Omentum, when strangulated is at first congested and of a dark red or purplish colour and later infiltrated and matted together After a time gangrene supervenes and it then becomes ashy grey or brown in colour and is pultaceous and friable. It does not become offensive unless associated with intestine. If however it has contracted adhesions to the sac and no gut is present, the trouble may subside since its vitality may be maintained through the adhesions.

The sac is usually distended with fluid which at the commencement is serous in character and perhaps blood stained this subsequently becomes turbid and mixed with lymph, and, finally it is dark brown or yellowish-green, with a marked and most objectionable odour Sometimes there is little or no effusion of fluid, a condition generally due to complete strangulation of arteries and veins simultaneously and often the precursor of early gangrene The serous lining of the sac is only slightly affected in the early stages as, however the case progresses, it becomes inflamed and ultimately gangrenous from the activity of bacteria, which by this time have penetrated to the turbid serum contained within it. The skin and surrounding tissues become œdematous congested and crepitant and finally a natural cure may be determined by sloughing and the establishment of a fæcal fistula.

Clinical History Strangulation is usually so characteristic that there can be but little uncertainty as to the diagnosis The general symptoms are similar to those described as occurring in all cases of acute intestinal

obstruction. The patient during some sudden effort notices a severe pain, localized at first to one of the hernial regions, or referred to the umbilicus this is accompanied by the usual evidence of shock, *i.e.* he feels faint, the pulse becomes slow and weak, the temperature falls, and he is covered in a cold, clammy sweat. This shock is often not very prolonged and is associated with or quickly followed by vomiting, at first gastric then bilious, and finally fæcal. As this continues, the pain increases in severity and radiates over the whole of the abdomen which becomes tense, tender and tympanitic. Symptoms of exhaustion supervene, caused partly by the pain and vomiting and partly by the inability to take food probably the absorption of toxic material also assists in its production.



FIG. 44 31 INTESTINE AFTER STRANGULATION IN A RICHTER'S HERNIA A PERFORATION HAS OCCURRED (*University College Hospital Museum.*)

Complete constipation is usually present, but the patient may at first pass flatus or fæces. The onset of gangrene is generally accompanied by a sudden fall of temperature and a cessation of pain gradually the pulse becomes weak rapid and intermittent, the surface is covered by a cold sweat the countenance becomes shrunken and drawn (the so-called *facies Hippocratica*) hiccough follows and the patient dies

Locally a tumour is found in one of the usual sites of a hernia, or the patient may notice that his rupture has suddenly become larger The swelling is irreducible, tense, extremely tender and painful and without impulse on coughing. It is hard and rounded if bowel is involved softer and more doughy to the touch if it contains omentum When gangrene ensues, the tension within the sac is reduced pain and tenderness cease and the skin over the tumour becomes dusky inflamed, and œdematous.

Richter's Hernia The early symptoms arising from strangulation of a portion of the lumen of the intestine are sometimes less marked than when a complete loop is constricted but the later phenomena are always very severe. It is usually of the femoral variety and the ileum is most frequently involved (Fig. 44 31) If less than half the circumference of the bowel is constricted the obstruction is not always complete at first flatus and fæces being sometimes passed but where more than half the circumference of the bowel is engaged, complete obstruction from kinking or paralysis of the gut ensues. The vomiting is less marked than in other cases and is not so commonly fæculent The tumour produced is small in size, but tense and tender It is quite possible however for it to be overlooked,

even when the groin is examined, and the diagnosis is then likely to be made either on the operating or post mortem table. The prognosis in these cases is always grave partly from the difficulty experienced in diagnosis partly from the tightness of the constriction Death usually results from peritonitis. A rare type of strangulation occurs in the so-called *Maydl's hernia* In this a W-shaped loop of bowel is involved the gut entering the hernial sac, then protruding again into the general peritoneal cavity re entering the sac before finally leaving it Strangulation may result in gangrene of the free loop of intestine and because this is not contained in the hernial sac, general peritonitis ensues

Treatment The operative treatment of strangulated hernia should be undertaken as soon as possible It is justifiable to try the effect of a simple enema in most cases and it is essential that a Ryle s tube be passed into the stomach and the contents aspirated before anæsthesia is induced. An intravenous infusion of saline solution should be set up at the same time and if the patient is shocked a blood transfusion can be given *via* the same needle. Anæsthesia may be general local or spinal but the first is to be preferred at all times if an expert is available to adminster it The incision is made directly over the swelling and the cause of strangulation looked for Usually it is the neck of the sac or an adjacent ligamentous band such as the pectineal part of the inguinal ligament. It should be divided from within outwards so as not to injure the bowel and it may help to insert a grooved director between bowel and constricting band in order to pass the knife more safely The gut is then drawn gently into the wound and wrapped in a pack which has been soaked in warm moist saline

The site of strangulation should be carefully inspected and a decision made as to whether it is viable or not. In the latter case, it is resected and end-to-end anastomosis performed. The gut is then replaced in the abdomen and the hernial orifice closed non-absorbable sutures should not be used as there is a risk of infection which might lead to their being discharged at a later date.

The post-operative care of a patient who has had a strangulated hernia is to continue gastric suction and give intravenous fluids until bowel sounds return. Penicillin and streptomycin should be given in full doses for five days, or longer if complications arise Further details about the management of this condition will be found in the chapter dealing with intestinal obstruction.

Chapter 45

THE STOMACH AND DUODENUM

Methods of Examination

The cardiac orifice of the stomach lies about 10 cm. behind the junction of the seventh costal cartilage with the sternum the highest part of the fundus reaches the fifth left rib in the mammary line the pylorus when the stomach is empty is in the middle line midway between the suprasternal notch and the symphysis pubis (Addison s transpyloric plane). When the stomach is full the pylorus passes more or less to the right of the middle line and descends slightly The lower border can usually be defined with tolerable accuracy by auscultatory percussion this is performed by applying a stethoscope over the centre of the stomach area and percussing outwards over the margin a change in note is readily recognized on reaching the border of the stomach

When the stomach is pathologically dilated the pylorus and lesser curvature are retained more or less in position by the lesser omentum, so that the organ pouches down towards the pelvis and becomes an elongated sac, in which fluids accumulate and decompose and gas collects. Peristaltic waves can often be seen crossing the viscus and on succussion or tapping the organ with the finger tips, gurgling and splashing sounds are heard

Radiography This is of proved service in demonstrating the activity and shape of the stomach after the administration of a barium meal, which consists of a mixture of 2 to 10 ounces of barium sulphate in gruel or suitably flavoured. X-ray photographs or screen examinations are then made at intervals, so that the changes in shape of the stomach as indicated by the shadow cast by the barium can be ascertained The greater curvature of the stomach should reach to a little below the level of the umbilicus (this owing to the weight of the barium meal) and the viscus should empty itself in about four hours. The shape of the pyloric end is also a matter of great significance, and so is the rate of emptying. Apart from the presence of actual ulcers or filling defects such as are caused by growths, the mucosal pattern is of interest. The duodenal cap merits especial study and the whole duodenum may be visualized by careful techniques.

Gastroscopy This has become a useful adjunct to the surgeon since the introduction of the flexible gastroscope. The use of this instrument requires much practice but in the hands of the expert it is a safe procedure accompanied by little discomfort for the patient, if he is suitably premedicated and the pharynx well cocainized, and one which gives visualization of the greater part of the stomach The movements of the stomach can be observed and ulcers on the lesser curvature and early carcinomas can be definitely diagnosed with this instrument. Duodenal ulcer and the juxtapyloric ulcer however remain invisible (Fig. 45 1 and Plate 7) and must be diagnosed by means of radiography

Gastric Analysis. Much may be learnt of the functions of the stomach by a careful examination of its contents and secretions. It is a simple and often very valuable procedure to remove the gastric residuum by means of a Ryle's tube and a 20 ml syringe. The patient is allowed no food or drink overnight, *i.e.* for twelve hours or more, and the contents of the fasting stomach are then withdrawn and examined as follows.

Chemically. The normal volume of the gastric residuum varies from 20 to 50 ml; a quantity greatly in excess of this suggests dilatation of the stomach. The average normal total acidity is about 0.11 g. per cent calculated as hydrochloric acid; the average normal content of free hydrochloric acid is about 0·07 g. per cent. About 10 per cent of healthy individuals, however, exhibit hyperchlorhydria, and about 4 per cent.

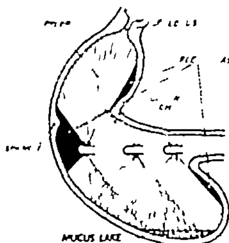


FIG. 45 1. DIAGRAM SHOWING THE EXTENT OF THE INTERIOR OF THE STOMACH SEEN BY THE GASTROSCOPE.

achlorhydria. The presence of organic acids, *e.g.* lactic acid, is pathological, indicating the existence of fermentation, which can only occur in the more or less complete absence of free HCl, because the organisms responsible for this change cannot thrive in an acid medium. The finding of blood may be significant, if one can exclude its origin from the gums or mouth, or from injury by the tube. The presence of bile denotes regurgitation from the duodenum, but this is really of little significance, as it has been demonstrated in a certain proportion of healthy individuals. There should not be more than a trace of mucus, and no starch should be present.

Microscopically. There should not be any cells, food residue or organisms other than those derived from the mouth by swallowing the saliva. In pathological conditions pus cells may be found, as also red blood corpuscles, endothelial cells, tubercle bacilli or tumour cells. Squamous epithelial cells are of no significance, being frequently detached from the mouth, pharynx, or œsophagus. Starch granules, cellulose remains, or undigested muscle fibres indicate great delay in digestion.

Bacteriological Examination. This is generally regarded as of little value. Boas-Oppler bacilli are fairly common whenever lactic acid fermentation occurs and are accordingly not unusual in gastric carcinoma.

Fractional Test Meal. A Ryle's tube is passed after a night's fast and the gastric residuum removed and examined (Fig. 45 2). With the tube

In situ a meal of oatmeal gruel previously strained through muslin is given, and at intervals of fifteen or twenty minutes a small sample (5 to 10 ml.) of the gastric contents is removed until the stomach is empty The acidity results are plotted, and the form of the curve examined. Considerable *modifications occur so that these records alone are not diagnostic of any* particular disease but must be considered in conjunction with the results of chemical and microscopical examinations and with the clinical findings.



Fig. 45 2. Aspiration of the Stomach.
A Ryle s tube is in the stomach and a 10 ml. glass syringe is attached to its free end.

The normal period for the complete disappearance of starch from the stomach is two hours or slightly less. *Hyperchlorhydria* is present in the great majority of cases of chronic duodenal ulcer and is not uncommon in other examples of reflex dyspepsia *e g* gall-stones or appendicitis, and pyloric lesions causing spasm of the sphincter *Achlorhydria* is present in many but in by no means all, cases of gastric carcinoma There is no constant finding in gastric ulcer An injection of histamine should provoke the secretion of acid in a normal or hypertonic stomach and insulin will give an indication of the amount of acid secreted by *vagal as opposed to hormonal stimulation* An *insulin test* meal is therefore of value in those patients in whom it is intended to perform vagotomy both as a pre-operative test and post operatively as a measure of the success of the operation.

Affections of the Stomach

Congenital Hypertrophic Pyloric Stenosis. Since this condition is exclusively confined to infants, it is more properly described in Chapter 39 which is concerned with pædiatric surgery

Thoracic Stomach. *The stomach may lie in whole or in part in the thorax* owing to a number of conditions. *Diaphragmatic hernia* which allows the abdominal viscera to pass upwards, is described in Chapter 44

Short Œsophagus This may be a congenital condition in which case it is presumed that during the descent of the diaphragm the œsophagus does not elongate sufficiently and in consequence the fundus of the stomach remains in the chest. Since however symptoms seldom develop before middle age and are then of a peptic ulcer type it is thought that other cases are acquired and that œsophagitis in the region of the cardia causes contraction and pulls *the fundus through* a dilated œsophageal hiatus. A skiagram of this condition is shown in Fig 42 2. Surgical treatment is

unsatisfactory for it is not possible to bring the cardia below the diaphragm If symptoms are very severe excision of the segment concerned may have to be undertaken with the establishment of an œsophagogastrostomy inside the thorax Recurrence of œsophagitis due to reflux is however likely

Hiatus Hernia In this condition a sac of peritoneum herniates along the left side of the cardia and the fundus of the stomach follows. A peptic ulcer often develops in the lower œsophagus. The treatment is operative if symptoms demand it and conservative measures fail An abdominal

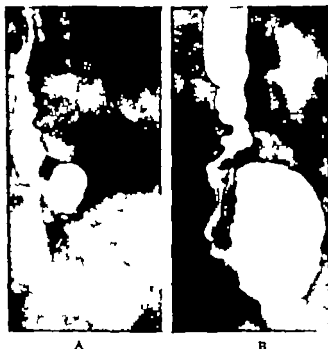


Fig. 45 3 Hiatus Hernia

A. Sliding Type. A small sac is seen above the diaphragm.
B. Rolling Type. Most of the fundus of the stomach lies above the diaphragm and displaces the lower œsophagus.

thoracic or combined approach may be made, the stretched œsophageal hiatus is closed with interrupted non-absorbable sutures so that the sac is completely obliterated and the cardiac end of the stomach is secured to the under-surface of the diaphragm This condition is also considered in Chapter 44

Rupture of the Stomach. This may result from blows or falls upon the epigastrium especially after a heavy meal and then usually involves the pyloric end or the greater curvature near the cardiac orifice. It may also follow a penetrating injury such as a stab or gunshot wound. Neighbouring viscera are not infrequently involved, especially the liver or spleen.

Symptoms There is severe and prolonged shock, with epigastric pain and vomiting, the ejected material sometimes containing blood acute septic peritonitis usually ensues in a very short time, causing rapid collapse and death. If however the wound is small or the organ empty there is little or no extravasation, and then a localized intraperitoneal abscess may form, shut off from the general peritoneal cavity by adhesions, but sooner or later bursting and discharging into the stomach, colon, or one of the

hollow viscera, or discharging at the surface Sometimes the barrier of adhesions gives way and a late general peritonitis results. If the posterior wall of the stomach alone is injured, the resulting phenomena are very similar to those due to the perforation of an ulcer in this region.

Treatment As soon as the diagnosis is tolerably certain, operation is performed A median incision is made above the umbilicus, the situation of the injury in the stomach ascertained, and the aperture closed by a double row of sutures which infold the margins and extend a little beyond the lesion at either end.

Foreign Bodies in the Stomach. These are either those which have been swallowed accidentally or intentionally or concretions, *e g* hairs, wool, etc due to the constant ingestion of small portions which remain in the viscus and after a time form large masses (*trichobezoar*). The presence of the former is known from the history while the latter give rise to symptoms of gastric irritation, the cause of which is inexplicable until the mass has attained such a size as to suggest the presence of a tumour The only treatment for a large foreign body is to open the organ and remove it (gastrotomy) where, however it is small, *e g* a coin, it may be allowed to pass onwards. Sharp objects must be viewed with suspicion but the pylorus is not such a barrier to the onward progression of a foreign body as might be thought.

Acute Phlegmonous Gastritis. This condition is due to bacterial invasion of the submucous coat of the stomach, which is infiltrated with leucocytes and fibrinous exudate together with many organisms, especially streptococci. This process usually ends in suppuration which may manifest itself as a diffuse purulent infiltration or as a more or less localized abscess or the whole mucous lining of the stomach may be cast off as a slough and vomited. Such a condition if not fatal from exhaustion toxæmia, or general peritonitis, will be followed by extensive stenosis, which may demand operative treatment The disease usually occurs in men who suffer from chronic dyspepsia, and is lighted up by overeating, excess of alcohol and occasionally the taking of corrosive poisons It may develop as a secondary result of ulceration or of operation. The symptoms consist of epigastric pain, persistent vomiting and marked restlessness, going on to delirium or collapse the pulse is quick and there is moderate fever The diagnosis is usually uncertain, perhaps that of a perforated ulcer being most commonly made At operation, if a localized abscess in the stomach wall is found, this may be drained and a jejunostomy instituted. Usually however the whole stomach is involved and in these cases some recommend the exteriorization of the whole organ, maintaining it in this position by a glass rod passed underneath it through the lesser sac, this latter also being drained and an enterostomy performed Multiple incisions are then made into the stomach wall to let out the pus.

Acute Dilatation of the Stomach. This is a curious condition occasionally met with as an unexpected and unwelcome sequel of injury or operation, not necessarily limited to the abdomen For example it may be associated with a fracture of the femur or an injury to the genitalia and it sometimes develops without apparent cause in the course of debilitating illnesses It is characterized by sudden onset, the vomiting of enormous quantities of fluid severe general symptoms of shock, dehydration and exhaustion and may terminate fatally in a few days. The stomach becomes enormously dilated and the walls are more or less paralysed, as peristalsis is rarely evident. The

pathology is uncertain but it is possibly due to constriction of the third piece of the duodenum by the superior mesenteric vessels and the root of the mesentery through a downward drag of the intestines Treatment consists in passing an intranasal Ryle's tube and instituting continuous stomach suction The vast quantities of fluid and electrolytes that the patient is losing must be replaced by the intravenous route



FIG. 45 4 ACUTE DILATATION OF THE STOMACH AS SEEN POST-MORTEM.

Duodenal Diverticulum. Congenital diverticula may occur in the duodenum as elsewhere in the small bowel Acquired diverticula are often multiple and are found protruding through the muscular coat on the concave



FIG 45 5 DIVERTICULUM OF THE DUODENUM WITH DIVERTICULOSIS OF THE COLON.
Note the rounded shadow in the second part of the duodenum, and also the extraluminal shadows due to diverticula, projecting from the transverse colon.

border They are often discovered accidentally on skiagraphy and seldom give rise to symptoms. If very large, they may cause pressure symptoms upon the pancreas or common bile duct and require removal.

Acute Gastric Ulceration. The ætiology of acute ulcer is probably quite distinct from that of chronic peptic ulcer Today it appears to be less common it affects mainly young women between the ages of twenty and thirty years and is associated with pain vomiting, and hæmatemesis, which, however is seldom severe. It starts probably as a small abrasion, crack, *or fissure, which deepens quickly and may thereby involve an arteriole and* cause bleeding Its progress is sometimes so rapid that perforation occurs, owing to the lack of a defensive reaction in the peritoneum It is probably

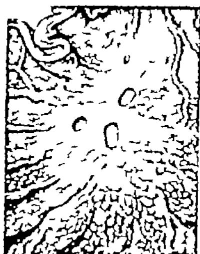


FIG. 456. ACUTE ULCERS OF STOMACH. (*King's College Hospital Museum.*)

due largely to an infective condition of the mouth and teeth or sometimes of the appendix or biliary passages. It is rarely more than 1 cm. in diameter and develops with almost equal frequency at any spot between the cardia and the pylorus along the upper margin of the stomach and more frequently on the posterior than on the anterior surface. It may be multiple two ulcers being often found opposite one another suggesting an infective origin. They are circular in shape and with the edges sharply defined and clearly cut each successive coat is destroyed to a less degree than the one internal to it, so that the ulcer is funnel-shaped Should perforation occur the opening is not central but slightly to one side These acute ulcers heal without much difficulty as is evident from the number of radiating cicatrices seen on the post mortem table. They give rise to no stenosis, except perhaps when they are actually situated within the pyloric orifice

Treatment This usually rests rather with the physician than the surgeon, but his assistance is always required in cases of perforation and he should always be consulted in cases of hæmorrhage The symptoms and treatment of perforation are very similar to those for the chronic variety and need not be discussed separately As the treatment of hæmorrhage the surgeon must never be tempted undertake operative measures in the hope of finding and dealing w point. The condition is rarely fatal, and reliance must ical measures, if complete

rest to the organ both physical and physiological the administration of morphine blood transfusion and intravenous glucose saline as indicated Other causes of gastric hæmorrhage connected with the portal circulation must also be borne in mind

Chronic Peptic Ulceration

In discussing chronic gastric and duodenal ulcers it is desirable to include them under the general heading of peptic ulceration as they have so many symptoms and signs in common and to point out in the course of the description the differences which are dependant on the site of the ulcer

Peptic ulceration is a condition which is said to occur at one time or another in 10 per cent of the population Although there are many known factors which are associated with the presence of the ulcer the cause is unknown. Many of these ætiological factors such as worry and fatigue are common to all humanity and yet only a proportion of those living under similar conditions are afflicted with the disease Peptic ulcer of a chronic type is more common in men than in women in the proportion of three to one, though the acute ulcer is more common in women Gastric ulcers are said to be becoming more uncommon and duodenal ulceration more frequent, but it must be pointed out that many cases of ulceration in the duodenum close to the pylorus, have been included in the category of pyloric and therefore gastric ulcers The proportion of chronic ulcers today occurring in the duodenum is, however five to ten times as great as those in the stomach. ✓

Ætiology Predisposition There seems no doubt that there are certain types (somatotypes) who may be said to be predisposed to either duodenal or gastric ulceration Duodenal ulcer is relatively common in the active, "full of energy" mentally alert and intelligent type of patient those so often found in the professions Barium meals in this type show a fairly small transversely placed stomach the so-called "steer horn" stomach, an appearance which is never associated with gastric ulcer These latter occur in patients of a rather dissimilar type the slow and rather sluggish, in whom X-ray reveals a somewhat toneless J-shaped stomach. These factors of themselves will not give rise to an ulcer but associated with other divergences from the normal the liability to ulcer formation is increased.

Acid Factor An increase above the normal in the free acid is present in peptic ulceration, this being greater in duodenal than gastric ulcer yet this of itself is not the only factor as is suggested by animal experiments where free acid, far in excess of that found in man has been introduced without ill result. The secretion of pepsin also has some connection with ulcer formation.

Traumatic Factor The majority of gastric ulcers (some 70 per cent.) occur along the lesser curvature of the stomach, about 20 per cent. in the pylorus, and the remainder elsewhere This peculiar liability of the lesser curvature has been explained by supposing that it is more subjected to trauma than other parts, as the gastric contents are propelled along this so-called *magenstrasse* The common site of duodenal ulceration in the duodenal bulb is similarly explained by supposing that this is always receiving the full impact of the gastric contents forcibly ejected through the pylorus.

Vascular Factor There is a comparatively poor blood-supply along the lesser curvature this has been suggested as a contributing cause in the production of ulceration in this region.

Toxic Factor It has long been known that peptic ulceration may be associated with septic conditions, such as may occur with *appendicitis*. It has been possible in animals to produce peptic ulcers by injecting non-hæmolytic streptococci (Rosenow) from human gastric ulcers. Hypothetically therefore, infection elsewhere in the body might be a contributory factor in peptic ulcer genesis.



FIG. 45 7 LARGE GASTRIC ULCER SITUATED ON THE LESSER CURVE. There is marked spasm of the greater curve.

Neurogenic Factor Cushing demonstrated in animals that release of the hypothalamic centres from cortical inhibition sometimes led to rapid perforation. Cushing's ulcer which is a duodenal ulcer occurring soon after extensive burns or scalds, may well have such a neurogenic factor in its ætiology

Vitamin Deficiency Factor A comparison of the foods in those parts of India where ulcer is rare and where ulcer is common has shown that in the latter there is a marked deficiency of vitamin A That this lack of vitamin may play a prominent part in ulcer causation is emphasized by the fact that in those districts where ulcer incidence is common, it is rare in the army where a well-balanced diet is taken

Diet Factor There is no doubt that alcoholic excess, heavy smoking, and the taking of highly spiced foods are associated in patients with an abnormally high proportion of peptic ulcer These factors are instrumental in producing a high gastric acidity and this as has been noted, is an essential for the production of ulceration

Pathology Peptic ulcers are usually single, although more than one may be present *This is of importance in* that perforation may occur at the same time from two separate foci In size they vary very much from the

minute duodenal ulcer to the longstanding gastric ulcer which may be 10 cm across. The very large ulcers are suggestive of malignant change. All coats of the stomach are involved in the eroding process and the whole is surrounded by an area of infiltration. This thick fibrous tissue probably accounts for the lack of natural healing in that the blood supply is diminished and healthy granulation and new epithelium are difficult to establish. The ulcer is covered

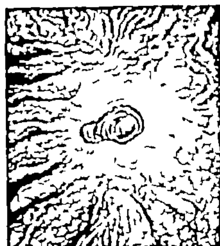


FIG. 45 8. CHRONIC ULCER OF THE STOMACH (*King's College Hospital Museum.*)

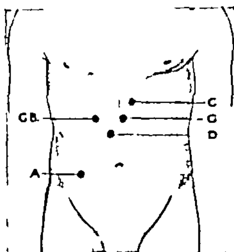


FIG. 45 9. TENDER SPOTS IN ABDOMINAL LESIONS.

C, In ulcer of stomach near the cardiac orifice. G in the ordinary type of gastric ulcer. D in duodenal ulcer. GB, in affections of the gall-bladder. A, in appendicitis.

by débris, under which is poor anæmic granulation tissue lying on hard fibrous tissue, and if it has extended to the peritoneal surface adhesions to neighbouring organs are likely to form. Old ulceration is represented by scarring on the outer side of the stomach and this may be so marked as to obliterate its lumen, with the production of an hour glass stomach or pyloric stenosis.

Malignancy occurring in gastric ulceration is most common in the region of the pylorus and although there is no uniformity of opinion it probably occurs in some 5 per cent.

Clinical Features. *Pain.* Classically the pain of which the patient complains is characteristic either of gastric or duodenal ulceration. In practice however such a distinction is less evident. The feature in both cases is intermittent, post-prandial epigastric pain alternating with periods of complete freedom. Each succeeding attack of pain tends to be worse than the last and the period of freedom shorter so that the patient seeks medical advice. In gastric ulcer the pain comes on soon after or even during the meal; in duodenal ulcer it comes several hours later and frequently wakens the patient from sleep in the night.

Vomiting. Unless a stenosis exists at the pylorus, this symptom is uncommon in duodenal ulcer but more frequent in gastric ulcer when vomiting may relieve the pain.

Hæmorrhage. The third classical symptom of ulceration may be so slight as to produce only occult blood in the stools, or may be so sudden and

excessive as to imperil life. A *hæmatemesis* results from a gastric ulcer *melæna* from a duodenal ulcer

The following table may be found helpful in summarizing the main differences between the two varieties of peptic ulcer

	Gastric Ulcer	*Duodenal Ulcer*
Sex Ratio.	M F=2 1	M F=4 1
Age.	Mostly 40–50.	Mostly 20–50.
Pain onset.	Soon after food.	2–3 hours after food. Wakes patient at night.
Pain relief of	By vomiting.	By food or alkalis.
Appetite.	Poor afraid to eat.	Good afraid to eat.
Vomiting.	Frequent.	Seldom.
Weight.	Considerable loss.	Some loss.
Tenderness.	Mid-epigastrium.	To right of midline.
Bleeding.	Hæmatemesis.	Melæna.
Perforation.	Common in males, uncommon in females.	Common in males, very rare in females.
Acidity	Variable.	Usually high.
Motility of Stomach.	Not increased.	Increased.
Cancer	5 become malignant.	Never become malignant.

Differential Diagnosis. Causes of epigastric pain are many and the following conditions must be considered cholecystitis, appendicitis, renal disease, hiatus hernia and short " œsophagus (both of which may lead to œsophagitis) chronic pancreatitis, angina pectoris, malignant disease affecting the stomach, colon or liver and of course dyspepsia of unknown cause. Radiography and the other investigations described at the beginning of this chapter will serve to make the true diagnosis



FIG. 45 10. DUODENAL ULCER.

The ulcer crater is seen as a barium-filled excrescence on the inner border of the first part of the duodenum, radiologically termed the "cap" or "bulb" The inner border and the outer border show general deformity owing to associated scarring and spasm.



FIG. 45 11 DUODENAL ULCER.

The cap is constricted by spasm into a typical trefoil shape. The ulcer which is on the posterior wall, and therefore covered by the barium in the cap can just be distinguished in the skiagram as a spot of increased barium density in the outer part of the inner leaf. On screening, the remainder of the barium could be expressed from the cap and the fleck of barium seen remaining in the ulcer crater

Treatment of Peptic Ulcer Gastric and duodenal ulceration should be subjected to medical treatment *in the first instance and this must* include attention to those factors suggested in discussing the ætiology of the condition, before any surgical operation is contemplated Duodenal ulcers respond more readily to medical treatment than gastric ulcers, although they are more likely to recur When, however this fails and even without the presence of any other complications, surgical intervention is indicated.

Many operative procedures have been described for treating peptic ulceration and this is a measure of the lack of uniformity of opinion as to which is best. Basically all are designed either to deflect the stomach contents away from the ulcer (*e g* gastrojejunostomy) or to remove the ulcer and the area from which it arose (*e g* partial gastrectomy) To these may be added a third method designed to reduce the acidity of the stomach (*e g* vagotomy) It is certainly true that at the present time the majority of surgeons favour partial gastrectomy for most patients. In reaching this conclusion, the factors which have been taken into account are the operative mortality the success of the treatment as judged by the relief of symptoms and the occurrence of later complications such as anastomotic ulcer

A description of operative methods follows later in this chapter

Complications of Peptic Ulcer Those complications calling for surgical treatment may be considered under the headings of hæmorrhage perforation, inflammation stenosis and recurrent ulceration.

Hæmorrhage This may present as already stated as hæmatemesis or melæna and is responsible for a high proportion of the deaths from gastric ulcer In the *acute* superficial form that occurs in young women it is usually derived from some small arteriole, but, as suggested above, does not require *operative treatment. Rightly handled it is not a fatal condition.* In the more *chronic* ulcers serious hæmorrhage may be derived from vessels of greater size and then may even prove fatal before help can be given. Thus one of the larger branches of the left gastric artery may be involved, or one of the enlarged varicose veins which are often found in the neighbourhood of an old ulcer where there has been much destruction of the posterior wall the base may be formed by the structures lying behind the lesser peritoneal sac, *e g* the pancreas, the splenic artery may then be opened and an immediate fatality result.

The treatment of this condition is one that calls for a fine degree of judgment in deciding when conservative treatment is to be abandoned and surgical treatment substituted. Most are agreed that if a hæmorrhage occurs, this should be treated at first by sedatives and a continuous-drip blood transfusion although some continental surgeons prefer to treat these patients by immediate operation. It is when the bleeding is not controlled at an early period by this treatment that the surgeon has to decide whether to persist with it for a little longer or operate at once. These patients are bad operative risks and some will when seemingly hopeless, recover with medical treatment. If operation is to be carried out it must not be delayed to a point where *the patient is so exsanguinated that little chance of survival is offered.* The age of the patient will also influence the decision on when to operate. Patients over 50 years tolerate blood loss much less well than the young and therefore in older patients, transfusion and early operation is likely to offer better results than a more conservative policy

Partial gastrectomy is by far the most satisfactory operation for hæmorrhage especially when the ulcer can by this means be excised Even when no bleeding point can be found partial gastrectomy should be performed as it involves ligating so much of the blood supply It is most unlikely that a bleeding point can be underrun with a suture, but occasionally an ulcer in the duodenum can be tamponaded by infolding the wall

Perforation. This carries the highest mortality in patients suffering from peptic ulcer It occurs more commonly in males than in females and in duodenal more than in gastric ulceration, the perforation in 90 per cent. being situated on the anterior wall. Perforation in acute cases of ulcer is rare When the perforation is situated on the posterior wall, it may if in the duodenum give rise to an infection about the kidney and this may track down in front of the psoas muscle ultimately forming an abscess in the region of the right iliac fossa which may mistakenly be diagnosed as an appendix abscess. Perforation from a posterior ulcer in the stomach may localize in the lesser sac of peritoneum giving rise to one form of subphrenic abscess, or it may cause an infection between the two layers of the lesser omentum Where the ulcer has been isolated by the formation of adhesions round about it, the ultimate perforation will give rise to a

perigastric abscess shut off from the general peritoneal cavity thus the patient will not manifest the signs and symptoms present when the perforation involves the whole abdominal cavity

Rarely the signs of a perforation are the first signs of any gastric lesion but usually the patient will give some history of dyspepsia

Symptoms These vary with the size of the perforation which may be minute or as much as 2 cm across, and also with the distension and condition of the contents of the stomach If there is much gastritis, they will be more heavily infected and obviously the onset of peritonitis is more rapid

The patient is suddenly seized with agonizing abdominal pain first referred to the centre of the abdomen but rapidly spreading all over There is a gross degree of shock although in the early stages the pulse rate is not raised although the pulse pressure is increased The patient lies perfectly still with his legs slightly flexed afraid to move because of the pain that such movement produces He is covered in a cold perspiration and is collapsed and the collapse may be so severe that death results from this alone. Vomiting occurs in half the cases. When examined it is found that the abdomen moves poorly with respiration is acutely tender at least in the right upper quadrant and possibly all over and that the muscles are rigid and "as hard as a board." Liver dullness is often absent on percussion and no bowel sounds are heard on auscultation After a few hours the patient feels improved and the shock is diminished but in spite of this and the improvement in the volume of the pulse the rigidity and abdominal tenderness persist If operation is delayed all the signs of diffuse peritonitis supervene.

Treatment As soon as a diagnosis has been made the patient s shock should be treated, morphine given to relieve the pain and the patient prepared for operation It is imperative to operate at an early hour because delay is associated with a rapidly increasing mortality

A paramedian incision is made and the ulcer sought for the area of induration and deposition of fibrin normally making this quite obvious. If the œdema is gross, or if the patient s condition is extremely poor the simplest procedure of tying a tube into the duodenum through the perforation should be employed. In other cases the ulcer should be closed by Lembert s sutures, which enfold and bury the ulcer the site of the lesion being reinforced if possible by an omental graft. A rapid inspection should be carried out to make certain that a second perforation does not exist It is unwise to wash out the peritoneal cavity and only where food is present is it necessary to do more than swab out the excess fluid. In cases where the perforation has been present for more than a few hours, drainage through a suprapubic stab wound should be instituted.

In recent years some surgeons have advocated additional or alternative procedures, such as partial gastrectomy or gastro-enterostomy but, in view of the low mortality associated with the simple operation of closure, this remains pre-eminent. Another view recently advocated is the conservative treatment of perforations. This is based on the observed fact that at operation a perforation is sometimes found to be sealed-off by omentum The treatment consists in gastric suction, intravenous fluid therapy antibiotics and morphine. If only because of the impossibility of differentiating the condition from others, such as perforated appendicitis,

this method is not to be recommended except on those rare occasions when there are no facilities for operation.

Perigastric Inflammation. This is a common result of ulceration it may be either adhesive or suppurative in character

Adhesive Perigastritis This is usually protective in nature consisting of a localized thickening of the serous wall It is more marked in connection with chronic than with acute ulcers. The posterior gastric wall often becomes adherent across the lesser sac of the peritoneum to the serous membrane lying in front of the pancreas, and this fixity may be one of the factors which prevent the ulcer from healing, even as fixation to the periosteum over the tibia delays healing in an ulcer of the leg.

In a few cases adhesions form between the anterior wall of the stomach and the parietal peritoneum. These may give rise to a localized fixed epigastric pain, usually increased considerably by distension of the organ internal strangulation or obstruction may also be caused by them. Such adhesions can sometimes be treated by division between ligatures.

Suppurative Perigastritis This may follow a perforation with limited leakage, but is more usually due to a gradual extension of the ulcer and an invasion of the perigastric tissues by organisms which escape from the stomach The result of this is the formation of what has been already described as a subphrenic abscess, which may or may not contain gas. It may burst anteriorly through the abdominal wall or may perforate the diaphragm giving rise to a basal empyema this in turn may burst into the lung or through the chest wall, so that fistulæ may appear in various places through which the contents of the stomach may be discharged

The abscess must be opened and drained but should a fistula form it is almost hopeless to attempt to deal with it locally and gastrectomy may then be required.

Stenosis. Either in the pyloric region or in the stomach itself peptic ulceration is always liable to produce cicatrizing stenosis. In addition, ulceration which has given rise to perigastric inflammation and adhesion formation may by virtue of this produce obstruction the adhesions either distorting the body of the stomach or dragging on the pylorus. Spasm of the stomach muscles, secondary to a peptic ulcer may simulate an organic obstruction, but this may be eliminated by the administration of belladonna

Pyloric Stenosis This results in about 8 per cent of cases of duodenal ulcer and in most of these patients it will be found that the ulcer is quiescent and healed. It occurs more commonly in males and at a younger age than stenosis due to an hour-glass obstruction Although the most common factor in producing this type of stenosis, other conditions such as carcinoma of the pylorus carcinoma of the head of the pancreas chronic pancreatitis, cholecystitis or carcinoma of the hepatic flexure may all give rise to it In addition there is sometimes found no factor to account for the stenosis these cases are believed to represent an adult form of congenital hypertrophic pyloric stenosis, a condition which is considered in Chapter 39

In an endeavour to overcome the obstruction, the wall of the stomach *hypertrophies, this eventually giving rise* to dilatation of such a degree that the viscus may fill the major portion of the abdominal cavity The patient will usually give a history suggestive of duodenal ulcer in the past He complains of a more or less continuous dull, full feeling in his stomach, accentuated by fluid and solid intake. He notices that he starts to vomit

that this relieves the pain and that the vomit is often very offensive and of large quantity The patient may when asked state that he has noticed that he returns particles of identifiable food taken many hours or days previously There is a loss of weight and appetite halitosis and increasing constipation



FIG. 45 12. PYLORIC STENOSIS.

On examination of the abdomen the outline of the distended stomach may sometimes be seen and rarely waves of peristalsis also Percussion confirms the great increase in the size of the organ and a sharp bimanual thrust given to the viscus may produce a splash, although no food or drink has been taken for hours previously A barium meal will confirm the diagnosis radiologically Treatment consists in performing a gastro-enterostomy after thoroughly washing out the stomach on each of several days previous to the operation.

Hour-glass Stomach This usually results secondarily to a horseshoe ulcer of the lesser curve of the stomach this, by its healing by fibrosis, drawing up the greater curvature until the cavity of the stomach is divided into a distal and a proximal segment, the latter undergoing hypertrophy and dilatation in exactly the same way as the whole stomach does in pyloric obstruction Rarely if two ulcers are present, the stomach may be divided into three compartments. The condition occurs in older patients and, in addition to being the end result of a healing gastric ulcer may exist as a congenital abnormality or be produced as a result of gastric carcinoma or specific ulceration, or occur as a result of perigastric adhesions.

The signs and symptoms are similar to those of pyloric stenosis, the patient, however giving a history of gastric as opposed to that of duodenal ulceration. According to the situation of the constriction, whether towards

the cardiac or pyloric end of the stomach, so the vomiting will follow rapidly on the intake of food or be delayed for some little while In *high obstruction* in hour glass cases the vomiting may follow so soon the taking of food as to simulate œsophageal obstruction

Treatment is necessarily operative but the patient s dehydration will



FIG 45 13 GASTRIC ULCER CAUSING HOUR-GLASS CONTRACTION.
Note the barium-filled ulcer cavity on the lesser curvature, and the deep incisura opposite it invaginating the greater curvature.

require adjusting and it is essential to wash out the stomach for several days before operation Though this may be difficult a partial gastrectomy above the stenosis must be performed Short-circuiting operations do not give such good results.

Anastomotic Ulcer This term is used to describe ulcers occurring in the region of the stoma following an anastomosis between the stomach and

intestine. They may occur actually along the anastomosis or an inch or so from it in the efferent loop but very rarely occur in the afferent loop presumably on account of the fact that it is here bathed with an alkaline secretion The causation of these ulcers is propably due to a persistence of the conditions producing the original ulceration although various factors, such as the using of clamps, or unabsorbable ligature material or the removal of redundant mucosa have been blamed in the past It is most common (occurring in some 6 to 8 per cent) where a gastro-enterostomy has been per formed for duodenal ulceration associated with a gross degree of hyper acidity even where a partial gastrectomy has been performed for this



FIG. 45 14 ANASTOMOTIC ULCER FOLLOWING GASTRECTOMY

condition the incidence of anastomotic ulcer is still appreciable, about 1 per cent. In cases where gastro-enterostomy has been carried out for gastric ulcer gastrojejunal ulceration occurs in some 4 to 5 per cent. of cases.

Where no ulceration into the neighbouring transverse colon has occurred, the chief complaint is of pain, situated in the region of the epigastrium, of a particularly severe type and less constantly related to food intake than in the case of gastric or duodenal ulceration *Vomiting, and the* administration of alkali nearly always relieves the pain Hæmorrhage in the form of melæna or hæmatemesis, may occur and be of such severity as to necessitate surgical intervention Perforation occurs in about *10 to* 15 per cent. of cases. It may be possible to see the ulcer through a gastroscope X-ray examination will often reveal one of several findings, *usually a*

stenosed or deformed stoma the presence of an ulcer crater or the retention of barium in this crater when the rest of the stomach is emptied

Treatment Initially a prolonged period of medical treatment should be instituted, but if this fails to cure the condition operation should be



FIG. 45 15 POSTERIOR GASTROJEJUNOSTOMY
The stomach has been brought through the transverse mesocolon for anastomosis to the jejunum.
A. The incision in the mesocolon. B The stomach being drawn through the mesocolon

advised. This may be of extreme difficulty and various measures have been tried but the best procedure of all is to carry out a partial gastrectomy

When a fistula occurs, either between the stomach and the colon or the jejunum and the colon or between all three the patient rapidly loses weight and goes down hill There is often severe vomiting the vomit containing

fæcal material and this is associated with intractable diarrhœa Pain is often conspicuous by its absence as in many of these cases the actual ulcer rapidly heals Operation which will consist in resection of the affected regions of the stomach jejunum and colon with restoration of continuity of the lumina carried out in either one or two stages, should be performed Some surgeons advise associating this with a partial gastrectomy and vagotomy The latter may alone be sufficient to ensure healing.

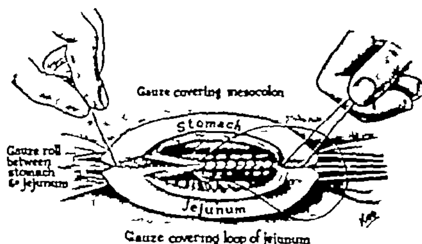


FIG. 45 16 POSTERIOR GASTROJEJUNOSTOMY
Introduction of first hæmostatic suture, after the seromuscular suture is completed.

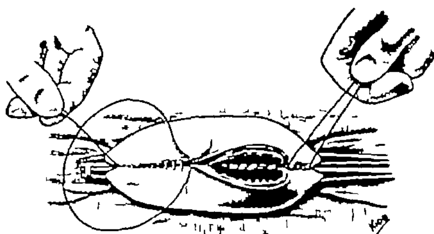


FIG. 45 17 POSTERIOR GASTROJEJUNOSTOMY
The return hæmostatic suture. The needle should pick up the mucosa as well as the muscle.

Operations upon the Stomach and Duodenum

Gastrojejunostomy The indications for this operation are the relief of pyloric obstruction, the treatment of active peptic ulceration or in association with other procedures such as vagotomy Pyloric obstruction may be

due to healed duodenal ulceration (and in such cases the operation gives excellent results) or to malignant disease A short-circuit may be justified as a palliative measure when the growth is inoperable Gastrojejunostomy is combined with vagotomy owing to the dilatation of the stomach which

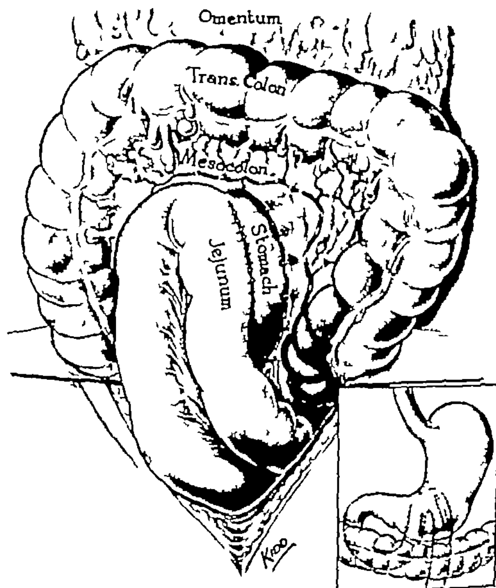


FIG. 45 18. POSTERIOR GASTROJEJUNOSTOMY COMPLETED

follows division of both vagi and the denervation of the pyloric sphincter

Various methods of performing the anastomosis are described

Posterior Retrocolic No-Loop Gastrojejunostomy This is the operation of choice A right paramedian incision is made and after examining the abdominal contents the duodeno-jejunal flexure is identified and the first loop of jejunum is withdrawn from the abdomen and covered with a hot moist towel. The omentum and the transverse colon are then drawn at right angles out of the wound and a comparatively bloodless area to the

left of the middle colic artery is identified in the mesocolon and incised The stomach is drawn through this orifice and manipulated until an almost vertical segment extending from the lesser to the greater curvature of about 3 to 4 in (7 5 to 10 cm) protrudes. The steps of the operation are shown in Figs. 45 15 to 18 A gastro-enterostomy clamp is placed on this a second pair being clamped to a loop of jejunum of similar length after this has been drawn just tight enough so that at the end of the operation there shall be no redundancy between the stoma and the duodenojejunal flexure The clamps are approximated in such a way that the proximal part of the jejunum lies against the lesser curvature end of the stomach (Fig. 45 18) A seromuscular continuous suture is then sewn approximating the similar walls of the two viscera. The stomach and jejunum are opened near the first suture line A second atraumatic needle and suture is then used to approximate all coats of the corresponding two walls of the stomach and jejunum towards the posterior aspect of the abdomen, and is continued to include those two situated anteriorly great care being taken to ensure hæmostasis and water tightness in turning from the one pair to the other The first seromuscular stitch is continued as a seromuscular stitch in front of the anterior stomach wall It is advisable, before stitching this layer to loosen the clamps so that any bleeding may be recognized and dealt with and when the final layer is sewn these are removed altogether

Finally before closing the abdomen the opening in the mesocolon is closed about the stoma, usually being stitched to the stomach any internal herniation is thus prevented

Anterior Antecolic Gastrojejunostomy In this procedure a long loop of jejunum is brought in front of the colon and an anastomosis is made with the front of the stomach wall. This operation is sometimes preferred by surgeons to that previously described, it is especially valuable in cases where the stomach is small where there is a gross amount of fatty tissue, or where the mobility of the organ is limited by adhesions obliterating the lesser sac, or attaching the stomach to the pancreas. An alternative in these cases is to bring the jejunum forwards through the transverse mesocolon, behind the colon, and to perform an anastomosis with the front of the stomach, the so-called *anterior retrocolic gastrojejunostomy*

Partial Gastrectomy This is the operation of choice for gastric ulcers, many duodenal ulcers, for innocent tumours of the stomach and some carcinomata. When the operation is performed for peptic ulcer an attempt is made to remove the acid-bearing area of the stomach by an excision of that part of the viscus distal to a line joining the upper third of the lesser curvature with about the juncture of the lower with the upper three fifths of the greater curvature. In those cases where the operation is performed for duodenal ulceration, removal of the first part of the duodenum is indicated, but in gastric ulcer this is not essential and not desirable, because the longer the duodenal stump the more easy is its invagination

The original operation, carried out by Billroth consisted, after excising the required area of the stomach, in re-establishing continuity by anastomosis of the duodenum with the proximal end of the stomach (Fig. 45 19) It was found that this operation somewhat limited the amount of stomach which could be removed and so it was replaced by the Billroth II method, in which both the cut end of the duodenum and the cut end of the stomach were closed and continuity established by means of a posterior gastro-

enterostomy The Polya operations similarly divided and invaginated the duodenal end and established continuity by means of a gastrojejunostomy In the Polya I method a no-loop retrocolic isoperistaltic anastomosis is performed while in the Polya II method a short-loop antiperistaltic anastomosis is made Balfour performed the same type of anas-

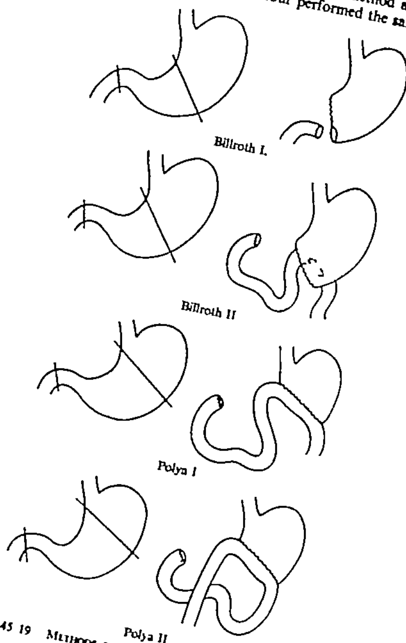


FIG. 45 19 METHODS OF PERFORMING PARTIAL GASTRECTOMY

tomosis but brought the jejunal loop up anterior to the transverse colon. Many modifications of these operations exist and text books of operative surgery should be consulted for details Hofmeister incorporated a "valve" in the anastomotic line by closing the upper or lesser curvature end of the anastomosis.

Through a paramedian incision the stomach is exposed, and the great omentum separated from its lower border the right and left gastro-epiploic arteries being divided The *lesser omentum* is similarly separated from the stomach after the right gastric artery has been ligatured. Two crushing clamps are placed on the pyloric end of the stomach or the first part of

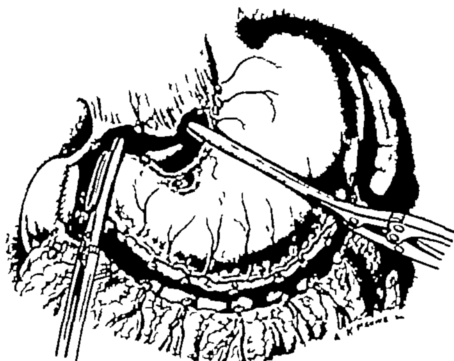


FIG. 45 20 PARTIAL GASTRECTOMY
Clamps applied and the duodenum divided.

the duodenum after the latter has been carefully separated from the head of the pancreas, and with a cautery or diathermy the viscus is divided between the two The duodenal stump is then closed by a continuous through-and-through stitch passing over the clamp the suture being drawn tight and tied as the clamp is removed. A further layer or two of Lembert's sutures serve to ensure absolute closure of the stump The stomach is drawn well over to the left and the left gastric artery identified and ligatured just proximal to the line along which resection of the stomach is to be performed A light non-crushing clamp is placed on the stomach again just proximal to the line of section A loop of jejunum is then chosen and this may be brought either *in front* of the transverse colon or behind it, through the mesocolon to the left of the middle colic artery In the Moynihan modification the jejunum is directed from left to right by the side of the stomach and in the Balfour modification from right to left, a second non crushing clamp being used to steady the bowel and aid in its approximation. A seromuscular stitch is used to sew the corresponding walls of stomach and duodenum together the suture in the former being placed just proximal to the line of resection. The stomach is resected and then, after opening the jejunum, the two viscera are sutured in much the same way as in a gastro-enterostomy

may have to be examined until one showing carcinoma cells is seen. The condition is much commoner in Holland than Great Britain. The fibrosis draws in all coats, but mostly in the submucosa, and it may be either diffuse or limited to the pyloric region. The stomach becomes eventually small and grossly contracted with a capacity reduced to two or three ounces.

In addition to local spread the growth usually gives rise to early lymphatic metastasis. The pyloric nodes are involved in growths situated towards the distal extremity and the coronary and paracardial glands in growths higher up. Lymph nodes in the region of the portal fissure become involved secondarily. From here growth may spread along the ligamentum teres to give rise to secondary deposits at the umbilicus. In about 2 per cent. the

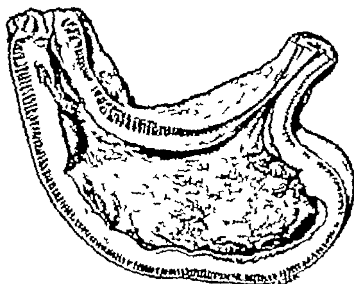


FIG. 45.25. LINITIS PLASTICA OF THE STOMACH. (*Royal College of Surgeons Museum.*)

thoracic duct becomes invaded and secondary deposits are formed in the left supraclavicular region, the so-called sentinel gland of Virchow being palpable above the inner third of the clavicle.

The extension of the growth outside the stomach will give rise to invasion of any of the neighbouring viscera, such as the pancreas, liver, transverse colon or mesentery. In addition, small clumps of cells may be detached and give rise to peritoneal transplants, especially in the pelvis, where they grow, subsequently giving rise to gross ascites.

Vascular invasion will give rise to secondary deposits in the liver, lungs, bone or brain.

Clinical Features. In 70 per cent. of patients dyspepsia of recent onset is the predominant symptom. In a further 20 per cent. there is a history of long-standing indigestion and possibly of proved peptic ulceration; the remaining 10 per cent. will be found to have advanced disease without any history of dyspepsia at all.

Any patient over forty-five complaining of symptoms suggestive of disease of the stomach, where previously none has existed, should be suspected of having carcinoma of the stomach until this is disproved. Complaint may be made of loss of appetite, vague feelings of discomfort and fullness after food, flatulence, or loss of weight. Some may come complaining of

PLATE 7



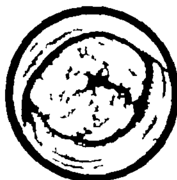
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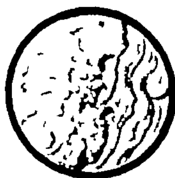
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GASTROSCOPIC APPEARANCES.

1 Closed pylorus.
2. Large benign ulcer on the posterior wall of the stomach, the floor of the ulcer being formed by the pancreas.
3 Multiple polypi on the posterior wall of the stomach.
4 Carcinoma of the pylorus. Ulceration has taken place.
5 Infiltrating carcinoma of the pylorus.
6. The stoma of a posterior gastroenterostomy

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In the late stages of the disease the patient becomes grossly cachectic and anæmic. Secondary deposits may be obvious in the skin or in Virchow's gland, and a mass is often easily palpable in the epigastric region. The leather bottle stomach can sometimes be detected as a solid mass emerging from under the left costal margin. The liver may be enlarged with deposits, ascites present due to peritoneal deposits or to pressure on the portal vein and the patient may be jaundiced if the nodes in the portal fissure are enlarged and pressing on the common hepatic or common bile duct. Pressure on the inferior vena cava will give rise to œdema of the legs and a varicose condition of the superficial abdominal veins.

Diagnosis. An opaque meal will invariably show an advanced growth as a filling defect, but may well miss an early case or diagnose as a simple ulcer what is in fact an ulcerated carcinoma. For this reason it is often necessary to repeat the examination after a month's interval. A simple ulcer usually shows as a smooth cavity whereas a malignant ulcer has an irregular outline (Fig. 45 27). But these differences are by no means always

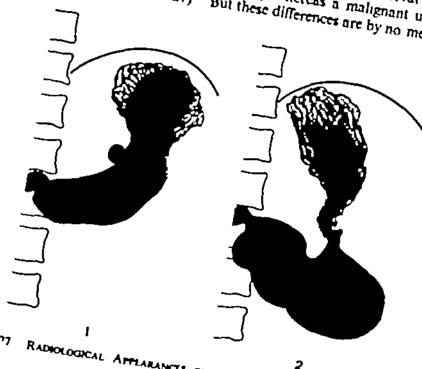


FIG. 45 27. RADIOLOGICAL APPEARANCES OF 1 GASTRIC ULCER AND 2 CARCINOMA OF STOMACH.

apparent. Gastroscopy has established itself as the most important ancillary investigation. In expert hands most regions of the stomach except the cardiac end and occasionally the pylorus can be inspected. A fractional test meal may actually mislead for the classical achlorhydria is seldom present in the early stages of the disease. Occult blood is always present in the stools except in cases of linitis plastica. A weight chart over a period of time is of the greatest value in determining whether dyspepsia is likely to be of innocent or malignant import.

Treatment. So few of these patients come into the surgeon's hands at a time when operation holds out a fair chance of success that every effort must be made to recognize these obscure symptoms earlier and in those

cases which fail to clear up with medical treatment an exploratory laparotomy is justifiable At present in only about 50 per cent of cases is operation with a view to radical procedure possible and in only 50 per cent of these can it be carried out When examination of the specimen shows the growth totally removed and no evidence of lymph node involvement, the chance of cure is reasonably good about half such patients surviving five years In practice it is the ulcer which is thought to be simple but is shown on histological examination to be malignant which is most often cured It is for this reason that some surgeons advocate a preventive gastrectomy for pre-pyloric ulcers of recent onset

Where pyloric stenosis is present in an otherwise inoperable case gastro-enterostomy will make the patient s few remaining months more comfortable but care must be taken to place the stoma as far from the site *of growth as possible to avoid invasion and occlusion Where the cardiac* orifice is involved the only operation of any value is a gastrostomy Stamm s method being that most commonly used A small incision



FIG. 45 28 CARCINOMA INVOLVING MOST OF THE STOMACH.

sufficient to take a No 12 *catheter is made into the stomach wall the* catheter being fixed by a purse-string suture surrounding it. Slight pressure is exerted on the catheter to invaginate it into the lumen of the stomach and it is fixed in this position by a second purse-string suture. Further invagination is carried out, and three, four or more similar sutures produce an "inkwell" effect. The stomach wall is then sutured to the peritoneum and the rectus sheath and the tube brought out through the top of the wound Sometimes the stomach is so contracted that it is impossible effectively to invaginate the gastrostomy tube and in these cases, Witzel s method should be employed. Here the tube is laid along the long axis of the stomach, after passing its end for an inch or so into the viscus, and it is fixed in position by a series of interrupted Lembert s sutures, sewing the seromuscular wall of the stomach over it Where the stomach is so involved by growth that a gastrostomy is impossible to perform a jejunostomy may if thought advisable be carried out.

Early radical extirpation then affords the only hope of cure. This implies the division of the stomach at least 5 cm. beyond the apparent edge of the growth the removal of the entire great omentum and the lymph nodes along both curvatures of the stomach, the subpyloric region, the cœliac axis and in particular those high up near the œsophageal hiatus on the left gastric artery In practice for a neoplasm not confined to the pylorus this means a total gastrectomy the spleen being also removed With growths of the lower œsophagus or confined to the cardia it is often possible to conserve the distal part of the stomach provided all the nodes can be cleared out. For this considerable operation careful pre-operative preparation by gastric lavage and blood transfusion are necessary and without doubt the best approach is an abdomino-thoracic incision Excision of the primary growth may be rendered impossible by involvement of the mesocolon or retroperitoneal structures, but it may still be justifiable as a palliative measure in the presence of hepatic metastases Direct spread to the left lobe of the liver or colon can be met by including the invaded portions of these organs in the *bloc* of excised tissue. After total gastrectomy an end-to-side or Y-anastomosis is performed between the œsophagus and jejunum

Another palliative measure which is sometimes of benefit is the insertion of radon seeds or short lengths of radioactive gold wire

Rare Neoplasms of the Stomach and Duodenum

Innocent Neoplasms. These are all rare but the following have all been recorded as occurring in the stomach myoma fibroma angioma, lipoma, adenoma and neurilemmoma These are usually discovered when gastric symptoms lead to a barium meal being performed The filling defect which is then shown tends to be smooth in outline and often larger than would be expected if a carcinoma were responsible for the symptoms. Gastroscopy will confirm the presence of multiple polyposis or a neural tissue tumour Gastrectomy which may have to be total is usually indicated.

Malignant Neoplasms. *Sarcoma of the Stomach* This is also very rare and may be round-celled or spindle-celled. It has been described in women of comparatively young age. The clinical features may be those of carcinoma or sometimes a large tense swelling develops in the upper abdomen in the absence of gastric symptoms Occasionally sarcoma of the stomach presents as an extrinsic tumour a readily palpable spherical mass is found at operation to be attached near the pylorus by a slender but very vascular pedicle.

Fibromatosis of the Stomach Considerable argument surrounds this condition which presents as a diffuse fibrosis of the submucosa At one time it was thought to be an innocent condition but it is now generally agreed to be a form of carcinoma and to be identical with that referred to above as linitis plastica.

Carcinoma of the Duodenum In contrast to the stomach, the duodenum is rarely the [illegible] carcinoma, and there is no relation between this and duodenal ulcer [illegible] wth [illegible] rule near the ampulla of Vater producing in [illegible] d [illegible] jaundice and symptoms of pancreatic [illegible] to say whether it is of duodenal or ampullary [illegible] s may sometimes be made by skiagraphy [illegible] in [illegible] on of the duodenum or in palliative [illegible] the third part of the duodenum

Chapter 46

THE SMALL INTESTINE AND APPENDIX INTESTINAL OBSTRUCTION

Methods of Examination

Radiography The jejunum ileum and appendix do not lend themselves very easily to examination but radiography is often of great assistance in the diagnosis of the condition and position of various lesions As already mentioned the stomach should be empty in about four hours and about the same time (four and a half hours) the barium should begin to enter the cæcum It is possible to follow the barium through the duodenum jejunum and ileum to the ileocæcal valve where there is usually some delay The hepatic flexure is generally reached in five to eight hours the splenic flexure in seven to fourteen hours and the iliac colon in eight to sixteen hours the barium is normally passed from the bowel in from twenty four to thirty-six hours. Irregularities in the course of the intestine can often be detected by this means, such as strictures kinks and diverticula The appendix can usually be visualized and account taken of the degree of filling and rate of emptying. Too much stress must not be laid on radiographic reports apart from a careful consideration of the clinical phenomena Barium is heavy and a downward displacement of the intestine when loaded with it is a natural consequence

The value of plain X-rays of the abdomen in the diagnosis of intestinal obstruction is referred to in the chapter which deals with that condition

Examination of the Fæces Biochemical tests give useful information as to the digestive function of the small intestines for instance the presence of undigested or unsplit fats suggest biliary or pancreatic disease. Occult blood may be present in the stools or the ova of various parasitic worms may be identified.

Affections of the Small Intestine

Congenital Conditions of the Small Bowel. The jejunum and ileum are subject to a number of errors of development which in the main, affect infants and children Such are the congenital atresias, stenoses and duplications of the gut there are also the varieties of obstruction which may result from incomplete rotation of the gut around the mesentery during intra uterine life These conditions are considered in Chapter 39 *Meckel's diverticulum* is also described in the same chapter

Injuries and Perforations of the Intestine. The causation, clinical features and treatment of these are described in Chapter 43

Foreign Bodies in the Bowel. These may be divided into three varieties

Foreign Bodies Swallowed Those that pass through the pyloric canal usually proceed without difficulty to the ileocæcal region. Apart from patients in mental hospitals, children are usually the subjects concerned. Sharp objects must necessarily be regarded with more anxiety than smooth

ones and serial skiagrams are necessary to check the position from day to day Sudden pain vomiting or signs of peritonitis call for immediate operation. *Contrary to popular belief it is unusual for foreign bodies to* lodge in the appendix though lead shot from eating game, are sometimes seen on skiagrams. Perforation of the bowel does not necessarily cause acute symptoms sometimes enough adhesions form and a localized abscess develops similar to that which may follow a ruptured appendix.

Gall-stones These cause no symptoms unless they are of large size the smaller ones enter the canal through the common bile-duct after an attack of biliary colic and are voided in the stools Larger stones usually gain entrance to the intestine by ulceration form the gall bladder into the duodenum A coating of fæcal matter is likely to form around them, thus they increase in size as they pass downwards, while the intestine gradually *diminishes in calibre from the duodenum to the ileum* so that they

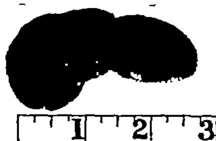


FIG. 46 1 TWO LARGE GALL-STONES WHICH ULCERATED INTO THE DUODENUM AND CAUSED INTESTINAL OBSTRUCTION.

are likely to become impacted in the lower ileum (Fig. 43 1). Women over *fifty are most often the subjects of this condition* and there may be only a history of some inflammatory condition in the region of the gall-bladder and none of biliary colic.

Enteroliths There are three types (*a*) Calculi of phosphate of lime or inspissated fæces form around some foreign body as a nucleus (*b*) Masses of indigestible vegetable material may be matted together with inspissated fæces, mucus, etc. they are said to be not uncommon in Scotland consisting largely of the husks of coarse oatmeal (*avenolith*). They have also been known to consist of hair or of coconut fibre in a patient engaged in mat making (*trichobezoar*) (*c*) Calculi have been found consisting of insoluble mineral salts, *e g* phosphate or carbonate of magnesia or calcium Whatever their origin, such enteroliths are likely to become impacted near the cæcum and may cause acute obstruction. In thin persons their presence may sometimes be detected by palpation of the abdomen.

Enteritis. *Inflammation of the mucous membrane of the intestine* is a condition usually treated by the physician, but occasionally it complicates a surgical operation and needs suitable treatment Thus it may follow the exposure of a coil of intestine in the depths of a wound which has to be packed for drainage purposes Severe diarrhœa may result and the inflammation may even spread through the whole thickness of the gut wall and lead to the establishment of a fæcal fistula Enteritis also occurs as a post-operative complication of strangulated hernia Whatever its origin it is always characterized by diarrhœa of varying type and by pain or abdominal discomfort and perhaps vomiting. Treatment consists in the use of a

bland diet e g milk and the administration of soothing astringent drugs such as bismuth and perhaps opium It must not however be checked without ascertaining so far as possible that the causative irritant has been removed Antibiotics are administered according to circumstances

Stenosis of the Intestine Apart from congenital causes stenosis is due to the contraction of adhesions or cicatrices or very rarely in the case of the small bowel, the presence of tumours.

Simple Stricture This results from (*a*) the contraction of adhesions outside the intestine following any form of peritonitis but particularly after pelvic cellulitis (*b*) the later stages of regional ileitis often cause stenosis (*c*) from the healing of ulcers which have extended more or less circularly around the bowel hence tuberculous ulcers lend themselves to its development more than the typhoid lesion (*d*) it may follow strangulated hernia as the result of ulceration along the actual site of constriction and similarly it may develop after the separation of an intussusception (*e*) an end-to-end anastomosis of the gut may lead to stenosis unless care is taken not to encroach too much on the lumen.

Since the contents of the small intestine are of a completely fluid nature a stricture often exists here for some time before any symptoms of urgency arise. The patient may complain of a certain amount of indigestion and discomfort, but sooner or later the narrow aperture of the gut becomes blocked either by a fold of mucous membrane or by a portion of undigested food and thus an attack of obstruction is induced. In the early stages of the disease this can be remedied by purgatives, but each recurrence is likely to increase in severity until finally an acute attack supervenes. The treatment must depend upon the cause but acute obstruction naturally calls for laparotomy

Enteroptosis. This very common condition sometimes referred to as Glénard s disease, consists in a general downward displacement of the stomach and intestines, and sometimes of the solid viscera as well (general *visceroptosis*) The cause varies, but sometimes the condition appears after an acute illness more usually it is chronic and develops gradually The relaxed abdominal wall which follows repeated pregnancies is often present and tight lacing used to be an important causative factor Women are much more frequently affected than men. The condition *per se* is not necessarily associated with symptoms but in a considerable number of cases marked neurasthenia is present. The amount of displacement is no measure of the severity of the symptoms. The stomach may well be below the costal arch, and when inflated stands out prominently both curvatures being visible it is usually distended atonically and succussion sounds may be heard. The transverse colon may sag downwards into the pelvis, and the kinking of the splenic and hepatic flexures thereby induced may be an element in the production of constipation. It drags on the duodenum and may give rise to symptoms erroneously attributed to gastric or duodenal ulceration.

Treatment This must be modified according to circumstances and due allowance made for the neurasthenic element. A course of rest and feeding is often valuable both for its influence on the nervous state and also in assisting to increase the deposit of fat Electricity and massage to the abdominal walls, together with appropriate remedial exercises, help to restore their tone and to improve the condition of the underlying viscera An abdominal belt or bandage will do much to relieve symptoms, especially

if applied with the patient in the Trendelenburg position. Operations designed to stitch up various organs, such as the stomach and transverse colon, have not stood the test of time and are not to be recommended.

Intestinal Stasis. The term was introduced to indicate what was considered to be an abnormal delay in the evacuation of the bowel contents. Lane considered that as a result of this, putrefactive changes occurred with absorption of toxins He and others drew attention to the presence in such cases of peritoneal bands which were supposed to be the cause of the stasis. It can be said that these views are no longer accepted and nor are the operations of partial or total colectomy which were once advocated Perhaps the only exception to this statement is that in cases of chronic constipation where a very pendulous cæcum has undergone torsion, it may be necessary to fix it to the posterior abdominal wall or to do a cæcoplication operation

Tuberculous Ileitis. Tuberculosis affects the bowel as well as the general peritoneal cavity (Ch 43). Tuberculous ulcers are usually multiple with undermined margins and extending along the course of the blood vessels and lymphatics, *viz.* around the gut so that when they heal stricture is likely to follow In their early stages they are seldom seen by the surgeon but later on obstructive phenomena may supervene and these may be due not only to the stenosis, but also to associated peritonitis neighbouring mesenteric nodes are usually infected, and together with the bowel and omentum may form a palpable mass, in the midst of which suppuration may occur Should the abscess burst externally a fæcal fistula may result. Operation may be needed for the relief of the obstructive phenomena, or for the suppuration and some form of short-circuit, or even excision of the mass, may be required.



Fig. 46 — Tuberculosis of the Cæcum.
Note stenosis of the ileocæcal valve and contraction of the ascending colon also calcified mesenteric lymph nodes to the left of the lumbar spine.

Ileocaecal Tuberculosis. A hyperplastic form of the disease limited in extent and producing a palpable tumour is not very rare. The clinical features are very similar to those of regional ileitis though in tuberculosis it is the cæcum which is mainly affected while in ileitis the disease involves primarily the terminal ileum. Very occasionally only the appendix is affected. The intestinal wall is thick, congested and infiltrated with a tuberculous deposit; the outer coat is rough and nodulated; the mucous lining is ulcerated and often presents vegetations and polypi of a granulomatous type; the mass is firm but not hard to the touch. Enlarged nodes are found in the mesentery and along the inner border of the ascending colon. Adhesions may be present and lead to kinking or twisting of loops of bowel. In the early stages, constipation and diarrhœa may alternate but later on obstructive phenomena may supervene or even well marked pyrexia of a hectic type. The diagnosis from a cæcal carcinoma is not always easy; the chief points in favour of tubercle are the earlier age (under forty years), the longer duration of symptoms (two or three years), the associated pyrexia and the presence of tuberculous lesions elsewhere. The diagnosis is, however not usually made until operation.

Treatment. If the disease is localized, resection of the affected bowel and mesentery should be done. In fact this usually means that a right hemicolectomy has to be performed. If this is impossible owing to the extent or fixity of the disease and if obstruction threatens, a side-to-side ileotransverse colostomy should be done. If tuberculosis is confirmed on section, sanatorium treatment and chemotherapy is advisable.

Regional Ileitis (*Crohn's Disease*). This disease occurs in an acute and chronic form. The former is almost always diagnosed as acute appendicitis,



FIG. 46.3. REGIONAL ILEITIS. The terminal ileum is narrowed and the cæcum and ascending colon are contracted and deformed.

but at operation a normal appendix is found associated with an acute inflammation of the lower part of the ileum No specific organism has been isolated from the affected bowel, but the disease so closely resembles hyperplastic tuberculosis that on occasions only a guinea pig inoculation with material from an involved lymph node will serve to differentiate the two conditions The pathological changes are much the same except that in regional ileitis submucous œdema is more marked caseation is absent and no acid-fast bacilli can be found At one time it was thought possibly to be a form of Boeck s sarcoidosis.

Clinical Features The terminal ileum is most commonly involved but the jejunum or cæcum may only be affected and rarely it occurs solely in the colon As stated the acute form resembles appendicitis the chronic form gives rather vague symptoms such as pain in the iliac fossa and epigastrium, vomiting and loss of weight Constipation is evident when the disease progresses to obstruction. Fistula formation, especially between ileum and bladder or rectum is not uncommon On examination a tender mass may be palpable Radiography confirms the diagnosis if the classical " string " sign is present this term describes the marked narrowing of the lumen of the terminal ileum Perianal sinuses are a common complication

Treatment There is a tendency for the disease to improve under conservative treatment and the acute variety is usually treated in this manner But the chronic type requires operation if only to relieve the obstruction. Resection of the affected ileum and mesentery with part of the ascending colon is advised Alternatively an ileotransverse colostomy may be performed to by pass the affected segment after dividing the ileum.

Fæcal Fistula. Both the foregoing conditions, tuberculosis and regional ileitis, are often associated with the development of fistulæ It is therefore appropriate to describe fistulæ in some detail.

Fistulæ may be of two types the *external* and the *internal* In the former the opening is in the skin in the latter the abnormal communication is with some viscus, *e g* the bladder The term *fistula bimucosa* indicates the existence of a communication with another section of the intestinal canal It may be of little importance if the affected segments are close together but should an opening be established between an upper and a lower segment *e g* between the upper end of the jejunum and the transverse colon nutrition will be seriously affected if the fistula is large enough to allow of the deflection of the greater part of the intestinal contents.

The condition may result from many causes, and these may be divided into the following groups (*a*) Those due to conditions inside the bowel such as the impaction of a foreign body this will lead to inflammation ulceration and localized peritonitis which will attach the affected coil of gut either to the abdominal wall or to some other viscus Suppuration occurs, constituting a localized intraperitoneal abscess which bursts either externally through the skin or internally into the attached bowel, and possibly permits the foreign body to escape If the cause thus disappears or is removed the fistula will often close spontaneously (*b*) Cases associated with primary disease of the intestinal wall are not uncommon and among them may be mentioned appendicitis, tubercle or actinomycosis, regional ileitis and malignant disease. Strangulated hernia sometimes results in the formation of a fæcal fistula in consequence of a localized gangrene of the bowel wall (*c*) Extra intestinal conditions may also lead to the establishment of

a fæcal fistula e g tuberculous peritonitis where an abscess forms outside the gut in the diseased peritoneal focus and opens both externally and internally this occurs most frequently in the neighbourhood of the umbilicus Wounds of the abdominal wall such as stabs would be included in this category (*d*) Finally one must mention the congenital variety resulting from the persistence of a *Meckel s diverticulum and this again is usually umbilical*

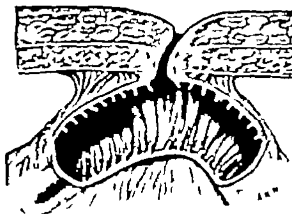


FIG 46 4 EXTERNAL FÆCAL FISTULA

in position and (*e*) *the post-operative where the fistula is made deliberately* for drainage irrigation, or feeding purposes

All these conditions are referred to in the various sections dealing with the disease in question

Actinomycosis. This rare disease attacks the appendix and cæcum more frequently than any other abdominal organ The disease usually originates from the *ingestion of infected material and the result is the production of* a hard, slowly-enlarging mass, infiltrating the tissues in the right iliac fossa Sooner or later the skin gives way and then the discharge of glairy pus and of the *yellow sulphur-like granules together with the musty smell, is* pathognomonic. Pyococcal infection of the sinuses is only too likely to follow sometimes originating from within the bowel the case then becomes complicated by a *suppurating element which has an important bearing on* the result. Even when, as a result of treatment, the condition subsides it is likely to recur after an interval elsewhere in the abdominal cavity Metastatic abscesses *may form in the liver the fungus reaching that organ via* the portal vein A " honeycomb " liver results and this condition is often fatal

Treatment The condition is seldom, if ever diagnosed before operation When the true nature of the disease is known, it should be treated by massive doses of penicillin (at least 1 million units daily) over long periods of time (at least three months) together with large doses of potassium iodide, up to 8g. (120 gr) daily Surgical excision of the affected bowel is seldom possible but short-circuiting may help to heal a fistula.

Amœbiasis. This disease most commonly affects the rectum and is described in Chapter 48 Uncommonly however it may occur as a localized mass in the ileocæcal region and here constitutes an *amœboma* which on clinical and radiological signs may be indistinguishable from a carcinoma.

In a patient who has been known to suffer from amœbic dysentery in the past it may be justifiable to delay laparotomy a short time to observe the effect of a short course of emetine injections.

Non-specific Mesenteric Lymphadenitis. This condition is described here owing to the marked affinity of its clinical features with appendicitis. The ætiology is uncertain but it is often associated with an upper respiratory tract infection such as tonsillitis. As the name implies there is no connection with tuberculous adenitis from which the nodes are distinguished by the absence of matting or caseation Children especially and young adults to a lesser extent are those affected and if operation is undertaken as is frequently the case on the assumption that acute appendicitis exists, the nodes are found throughout the mesentery but especially in relation to the terminal ileum, and to be enlarged, soft and pink.

Diagnosis The symptoms are very much the same as those of catarrhal appendicitis Perhaps the temperature is higher than one would expect, the pain more generalized and colicky and in the intervals between pain the child feels better than with appendicitis. He is seldom able to locate the point of maximum pain with such exactitude and the same is true of the tenderness on examination it is more generalized in the right iliac fossa and may shift to the left if the patient is turned on his left side Though the diagnosis may often be made with confidence it must be stressed that in children it is often unsafe to wait and no surgeon need feel ashamed of operating unnecessarily where appendicitis is concerned.

Treatment It is claimed on the grounds that the condition previously recurrent, is cured by operation, that appendicectomy is the correct treatment. But this seems an illogical conclusion and indeed attacks of pain often persist. The fact is that time tends to cure the attacks and there is also the point that a patient or a child s parents may make light of a pain previously thought to be caused by the appendix once that organ has been removed

THE APPENDIX

Appendicitis

Appendicitis is an affection which may appear at any time of life but it is most common in young adults, the male sex being more frequently attacked than the female. The disease is sometimes of only slight significance but occasionally runs such a virulent course as to destroy life in a few hours. Its importance lies in the fact that it is an infective process, and inasmuch as the peritoneal cavity is generally involved a certain degree of peritonitis is almost necessarily a consequence

Ætiology Many different conditions contribute either directly or indirectly in determining an attack of appendicitis. (*a*) The appendix is usually looked on not as an actively functional structure, but as a degenerated relic of little importance It often has but a poor blood supply derived from the posterior ileocæcal branch of the ileocolic artery (*Fig. 46.5*). The main nutrient vessels run along the free border of the meso-appendix, but a second twig often runs down the base of the mesentery (*b*) A large amount of lymphoid tissue is present in the mucous membrane especially in young people, so that the title of "abdominal tonsil" has been applied to it The lymphoid follicles have a tendency to atrophy with advancing age Bacteria are constantly found within the lumen and in the lymphoid

follicles, and inflammatory processes are set up by them within its walls (c) Its length and direction vary considerably in different individuals. *In length it may measure anything between 1 and 6 in (2 5 – 15 cm)* but is usually about 3 in (7 5 cm) long obviously added length means increased liability to harmful kinks and twists As to direction it may lie in any axis and the clinical picture is *largely influenced by its anatomical position* The

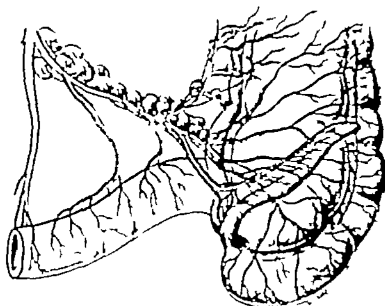


FIG. 46 5 THE POSTERIOR SURFACE OF THE CÆCUM, SHOWING THE BLOOD SUPPLY AND LYMPHATIC DRAINAGE OF THE APPENDIX.

commonest situation is behind the cæcum and ascending colon directed upwards (Fig. 43 6) but it is not unusual for it to overhang the pelvic brim and then *pelvic complications almost always accompany an attack of appendicitis.* When the appendix lies to the outer side of the cæcum the inflammatory reaction may be more localized (*d*) The extent of attachment of the meso-appendix *is an important element since the portion which projects* beyond its free border is less well supplied with blood The mesentery often does not extend beyond the junction of the middle with the distal third and *perforation not infrequently occurs about this spot.* (*e*) The communication with the cæcum is usually small and is guarded by an insignificant fold of mucous membrane known as the valve of Gerlach. *Sometimes this aperture becomes blocked, or the orifice stenosed, as the* result of a preceding inflammation of the mucous lining of the cæcum so that an accumulation of mucus occurs within the appendix, leading to its dilatation into a *cyst-like pouch* (*f*) *The content of the normal appendix* consists of a little mucus and a certain number of bacteria similar to those found in the neighbouring intestine a generalized infection of the intestinal canal, will obviously *add to this number* Foreign bodies, such as pips, pins, etc. are occasionally found within it, and by their presence and irritation may light up an attack of appendicitis. They are much less common than was formerly imagined and *the fact that the opening into the intestine is* generally not larger than to admit a small catheter will explain this rarity Fæcal concretions are comparatively common they are oval bodies varying

from 1 to 2 cm in length and usually laminated consisting of dried fæcal material mixed with myriads of bacteria, and perhaps with a pip or foreign body as a nucleus They are not very hard, and can easily be cut with a knife or even crushed between the fingers Occasionally they can be recognized in a skiagram of the pelvis taken for other reasons. (g) Appendicitis

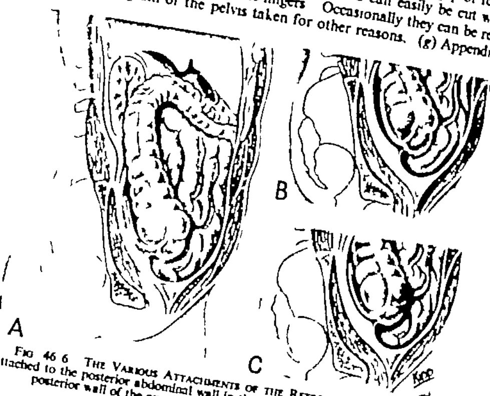


FIG 46 6 THE VARIOUS ATTACHMENTS OF THE RETROCÆCAL APPENDIX. A, Attached to the posterior abdominal wall in the right iliac fossa B, Attached to the posterior wall of the cæcum. C, Lying free in the retrocæcal fossa.

is occasionally associated with a true typhlitis (inflammation of the cæcum) or with a more generalized colitis Dysenteric ulceration may involve the appendix, or lead to stenosis of its orifice but it is rarely implicated in typhoid fever (h) Injury in the shape of a strain or sudden twist is sometimes mentioned as the cause of an attack, and probably acts by displacing a long



FIG. 46 7 APPENDIX TIED DOWN BOTH TO THE CÆCUM AND THE ILEUM, AND DOUBLED ON ITSELF BY OLD-STANDING ADHESIONS.

appendix in such a way as to lead to kinking and possibly obstruction of the nutrient vessels When a concretion is present it may modify the vascular conditions around it

There can be no question as to the greatly increased frequency of appendicitis at the present day especially among those who live in large towns or cities It is difficult to assign any one cause to this but changing habits of diet may well be an important factor

Pathological Anatomy *Appendicitis* is an infective malady due to invasion of the walls of the appendix by organisms especially the *Streptococcus pyogenes* the *Esch coli* and other intestinal bacteria. These find an entrance into the wall of the appendix either through an eroded area of the mucous membrane, due to the impaction of a foreign body or of fæcal concretion, or else they are absorbed into the lymphoid tissue so abundantly present and are able to overwhelm the protective mechanism provided thereby The results may best be described under the following headings

Changes in the Appendix In the simpler forms a mere catarrh of the appendix results The organ looks red and swollen and its peritoneal



FIG. 46 8. APPENDIX WITH A STRICTURE AT THE PROXIMAL END



FIG 46 9 DIVERTICULITIS OF THE APPENDIX

surface may be smooth or roughened by loss of endothelium and deposit of lymph It feels stiff from effusion and has lost its natural flexibility The muscular coats are often infiltrated with leucocytes and this is especially noticed around the hiatus muscularis, through which the vessels enter The mucous membrane is thickened engorged and infiltrated with polymorphonuclear leucocytes, and here and there erosion or ulceration is present If the process goes no further healing occurs after a time and is often associated with fibrosis, which may show itself as a generalized sclerosis of the whole appendix, a stricture of the lumen (leading later to an empyema) or complete obliteration may occur Occasionally small diverticula form as the result of a hernial protrusion of the mucous membrane through some gap in the muscular wall, *e g* the hiatus muscularis They are usually not larger than a hempseed but are of importance, since the thin walls readily give way and thereby a general peritonitis may be lighted up

More severe infection leads to suppuration in various forms. Mucopus collects in the lumen and may lead to perforation. Necrosis or gangrene is due to an acute interstitial inflammation spreading from an impacted concretion or from an ulcer of the mucosa, or results from kinking and thrombosis of the appendicular vessels in the meso-appendix. The whole appendix may slough, or merely a portion, and then usually the tip or the part immediately opposite the distal end of the meso-appendix. The necrotic tissue is soft and easily torn, of a blackish, brown or green colour and always extremely offensive.

Changes in the Cæcum. These are usually also present. In the *catarrhal* variety a generalized inflammation is often present and perhaps it would be more correct to speak of appendicitis as a complication of that condition. In *suppurative* appendicitis that part of the cæcum in contact with or in continuity with the appendix is generally inflamed and infiltrated, but rather from the peritoneal aspect than from within. Rarely does the inflammation become so severe as to lead to suppuration or necrosis of the wall of the cæcum; should this occur, it usually involves the base of the appendix, and may be followed by a fæcal fistula.

Peritoneal Phenomena. These are of the utmost importance.

In the milder cases the peritonitis is protective in type. The serous coat of the appendix becomes inflamed, sheds its endothelium, becomes roughened by a deposit of lymph, and this results either in a thickening of the wall or in a formation of adhesions which tie down the appendix in various directions. Most commonly it is simply fixed to the cæcum along part of its length, but sometimes it is firmly united to it for its whole extent. Adhesions may develop between the appendix and the omentum, the mesentery or ovary, etc.; in fact, it may be united to almost any of the viscera and may thereby give rise to some form of acute obstruction. It may also contract adhesions to the fascia over the psoas sheath or iliac vessels.

In the more serious cases an infective peritonitis occurs and a *localized intraperitoneal abscess* is by no means uncommon; its extension is limited by the formation of adhesions between the omentum, parietes and neighbouring coils of intestine. Its exact anatomical relations depend on the original situation of the appendix. Frequently it is located below and behind the cæcum; sometimes it burrows down into the pelvis. In other cases it passes inwards among the intestines, or it may track up towards the liver either on the inner or outer side of the ascending colon.

Sometimes, when the general health is good and the infection not too virulent, the abscess may remain quite limited and the pus be completely absorbed, inspissated and encapsulated. At other times, it may rupture into a neighbouring viscus (especially the rectum) or into the general peritoneal cavity. Cases are seldom seen where the pus tracks to the surface of the abdominal wall because most patients come for treatment before this occurs. The pus contained in the abscess is usually of a stinking character, and in cases of sloughing of the appendix the fœtor may be intense; but the amount of smell is no gauge of the virulence of the process. Sometimes the débris of a broken-down concretion can be recognized in the pus and sometimes a portion of the appendix as a slough. Gas is also present in some cases, having escaped from the bowel or been generated by the activity of gas-producing organisms, of which the *Cl. perfringens* is the most important.

In the worst cases a *spreading septic peritonitis* is observed with little tendency to localization The line of diffusion is governed by the anatomical relations of the appendix If it is situated above the brim of the pelvis and on the outer aspect of the cæcum the effusion may extend to the right kidney pouch and a subphrenic abscess be determined if it is on the medial aspect of the cæcum the effusion will probably be limited by the mesentery to the lower half of the abdomen and will occupy the pelvis and right iliac fossa

Clinical Features. *Catarrhal Appendicitis* The mild type of disease to which is added a localized plastic peritonitis usually commences somewhat suddenly though the attack may be preceded by malaise and abdominal discomfort The patient is seized with pain at first referred to the umbilicus



FIG. 46 10 AN APPENDIX PARTLY FILLED WITH BARIUM, SHOWING SEGMENTATION.

or to any part of the abdomen but at the end of twenty-four to forty-eight hours it localizes itself in the right iliac fossa it is often of a sharp cutting character but varies much in intensity and duration Fever is usually present and the patient complains of nausea and vomiting, but the latter symptom does not last long. Constipation results, but in children it is sometimes replaced by diarrhœa, which may be blood-stained, so that the condition may even be mistaken for enteritis.

On examination the patient may look flushed and ill with furred tongue and halitosis. The abdominal wall is found to be more rigid than usual, especially over the right iliac fossa and the right leg is often drawn up to relax the psoas. *Definite tenderness is noted on pressure and the patient will often*, but by no means constantly refer it to a spot about 2 5 to 3 cm from the anterior superior iliac spine along a line drawn to the umbilicus (McBurney s point). Sudden lifting of the hand after deep pressure often elicits sharp pain in appendicitis or other inflammatory lesions (rebound tenderness) In many cases, when the appendix is directed backwards,

there is marked tenderness in the lumbar region but if it points downwards into the pelvis, the pain and tenderness may not be evident except on rectal or vaginal examination, which should never be neglected A definite swelling may sometimes be detected by palpation, usually above the outer half of the inguinal ligament but varying in its position with the site of the appendix it may be dull on percussion, but is frequently tympanitic, since it consists of coils of intestine and omentum matted together around the appendix (appendix mass)

Cutaneous hyperæsthesia is manifested in more than half the cases of appendicitis. It is demonstrated either by stroking with a pin-point held at right angles to the surface, or by light pinching. In the former the two sides of the abdomen must be tested, as also the regions above and below the appendix area, which is usually contained within the triangle marked out by the midline the inguinal ligament, and a line drawn horizontally outwards from the umbilicus (Sherren's triangle) In the pinch test, corresponding portions of skin are gently pinched between the thumb and finger on both sides of the abdomen the patient estimating the difference in sensation. The area of hyperæsthesia varies with different viscera, but it is uncommon to find it present in the absence of peritoneal inflammation. The appendix area corresponds in the main with the distribution of the tenth thoracic nerve

An important aid to diagnosis in many mild cases especially in the presence of adhesions, is the causation of pain in the region of the appendix by pressure over the *left* side of the abdomen directed towards the middle line. In not a few cases tenderness is also noted along the inner border of the ascending colon and upwards towards the navel this is probably due to swelling of the mesenteric nodes which on operation are often found enlarged and congested

Gangrenous Appendicitis The inflammation in the appendix may proceed so rapidly that the small vessels become thrombosed and general peritonitis results. Such a condition is recognized by increasing pain in the right iliac fossa spreading until it is generalized over the abdomen and associated with rigidity The patient looks ill and toxic, with high temperature and rapid pulse with perhaps rigors. Vomiting becomes frequent and unless operation is undertaken at an early date death will result

Appendix Abscess In cases where the infection is less virulent the appendix may become inflamed and even gangrenous but the process is less rapid and the infection is walled off by the natural body defences when a localized abscess or mass forms The appendix is surrounded by the omentum and walled off by many adhesions between it and the cæcum and the adjacent small intestine The abscess develops round the appendix and is primarily intraperitoneal. Occasionally it bursts into the bowel and thereby relief is gained without the assistance of surgery some authorities indeed, maintain that this occurs in every case of the more severe type which resolves. In other instances it may behave in the manner already described giving rise to a subphrenic or pelvic abscess or to general peritonitis

Sometimes the patient's general symptoms improve after the first attack the temperature may become normal the pain decrease and the vomiting cease It is often difficult to be certain whether this improvement is merely temporary or is the start of a true subsidence of the condition. It is this *interval of quiescence* which especially in the case of children may lull the

practitioner into a sense of security which is later belied It cannot be emphasized too strongly that if a diagnosis of appendicitis has once been made subsequent improvement in the symptoms should be regarded with suspicion When gangrene of the appendix, or part of it has occurred the early acute pain and cutaneous hyperæsthesia may disappear entirely and the patient feel fairly comfortable the pulse is however usually rapid and the general appearance bad there may also be well-marked local rigidity

Obstructive Appendicitis There is a distinctive variety of appendicitis caused by complete block of the lumen of the appendix due to kinking, band or stercolith The patient is seized with pain and tenderness in the right iliac fossa and vomiting there may be no rise in the pulse rate or



FIG. 46 11 A LARGE STERCOLITH IN THE APPENDIX

temperature in the early stages, but examination reveals a local rigidity and tenderness which does not correspond with the constitutional symptoms. Continued vomiting is the feature of this variety which is not surprising when it is considered that this is a form of intestinal obstruction

Immediate surgical treatment is called for in these cases, as perforation is liable to occur at any moment, with a spreading generalized peritonitis.

Recurrent Appendicitis This is characterized by repeated attacks of varying gravity in an individual who has once suffered an acute attack They may occur only at prolonged intervals, or be so frequent as entirely to incapacitate the patient They are usually associated with the presence of some abnormal adhesion or constriction It is not uncommon for the appendix to become fixed to the sheath of the psoas muscle and then any excessive movements of the limb may light up an attack Where stenosis exists secretions containing bacteria may be pent up and from time to time the patient suffers from severe pain of a colicky nature with or without fever probably due to an attempt to get rid of the excess of mucus Such

attacks have been named *appendicular colic* In a few cases the appendix becomes totally obliterated after a time and incorporated in a mass of adhesions, a natural cure being thus established more frequently the patient finally develops an acute attack which demands operation.

Appendicular Gastralgia This term is applied to cases in which all the signs and symptoms of the disease are referred to the epigastrium and closely mimic those of a gastric or duodenal ulcer The patients are usually women and a test-meal examination reveals a hypersecretion of gastric juice in which the hydrochloric acid is usually increased. Laparotomy shows no lesion in the stomach or duodenum but chronic appendicitis is present. That the previous symptoms were due to the appendix is proved by the relief of the symptoms and the changes in the gastric secretion after appendicectomy

On the other hand it must not be overlooked that a gastric or duodenal ulcer is often accompanied by pain referred to the right iliac fossa and many an appendix has been removed without benefit to the patient for these conditions The history of the condition must be most thoroughly investigated Pain in gastric or duodenal lesions is more persistent than in appendicitis and the intervals of freedom between attacks shorter Vomiting, too is less marked in appendicitis and does not give the relief experienced in duodenal lesions. A barium enema is often of help in these conditions, as the appendix may show kinking or failure to fill or on screening, tenderness may be elicited by palpation over a partially filled appendix.

Chronic Appendicitis It is a matter of argument among clinicians whether chronic pain in the right iliac fossa is due to chronic inflammation of the appendix. Certainly this symptom is exceptionally common especially in young women who are a little constipated A great many appendices are removed on this account sometimes with, but often without benefit. Before agreeing to operate the surgeon is well advised to consider all other possible causes of the patient s symptoms

Diagnosis of Appendicitis. In a well marked case the symptoms are so typical that the diagnosis can never be in doubt The pain, tenderness, fever vomiting, constipation, abdominal rigidity and perhaps swelling constitute a picture that is quite characteristic. A raised white blood cell count of more than 12,000 is also suggestive while if it should be 20,000 or more it can be taken as diagnostic of intraperitoneal infection The disease however often presents symptoms so varied, and manifestations so protean, that one is never surprised to meet with it in all sorts of diverse settings. It is in the very young, the very old and the very fat that the difficulties of diagnosis are greatest.

Mesenteric adenitis may be extremely difficult to distinguish from appendicitis especially in children This condition is described on page 1116.

The early stage of *pneumonia* is sometimes associated with severe pain and tenderness in the iliac fossa, especially in children and the resemblance to appendicitis is more marked when the onset is sudden and abdominal rigidity and vomiting are present the abdominal symptoms are probably due to the existence of a diaphragmatic pleurisy It will be noted that the pain is superficial and that deep pressure is painless if made carefully A careful examination of the lungs should never be omitted in any case of suspected appendicitis Cases which start with diarrhœa may be mistaken for *enteritis* while *constipation* may often occasion difficulty especially in

children In such cases there may be severe colicky pain but the classical physical signs are absent *Acute pyelitis* too sometimes simulates appendicitis, but as a rule the temperature is higher the abdominal muscles are relaxed the tenderness is placed deeply in the loin and pus and bacteria are present in the urine. Occasionally however the appendix is in close contact with the ureter as it crosses the brim of the pelvis and then hæmaturia and even renal colic may be caused In such cases the renal region is free from tenderness and the pain is situated at a lower level

Perforation of the duodenum or *stomach* may lead to symptoms very similar to those of acute appendicitis. The initial pain will usually be referred to the upper part of the abdomen and there may be evidence of free gas in the peritoneal cavity If gas escapes from the abdomen on operation and is free from odour the probability is that the lesion is gastric or duodenal *Mucous colitis* simulates chronic appendicitis and the appendix is indeed often also involved The distinction is made by the tenderness being located over the whole course of the colon and by the passage of mucus in the stools *Tubal* and *ovarian* diseases are recognized on pelvic examination and on the history But it must be admitted that chronic appendicitis and chronic ovarian pain are often diagnosed on insufficient grounds A small ovarian dermoid with a twisted pedicle may resemble appendicitis very closely

Spinal tuberculosis may be the cause of psoas spasm or abscess which may mimic appendicitis. Suppuration in the *deep iliac nodes* may give difficulty in diagnosis, but the vomiting and abdominal pain of appendicitis are not present, and a focus of infection on the lower limb may usually be found.

In persons above middle age *carcinoma of the cæcum* is of differential diagnostic importance from an appendix mass. Both conditions may give rise to much the same symptoms and in both a tender mass is palpable The neoplasm however is more discrete and mobile while it is seldom possible to get between the appendix mass and the iliac crest.

Treatment. *Acute Appendicitis* There is little doubt that the correct treatment of catarrhal appendicitis, considering the difficulties in assessing what course the infection is going to take and what actual pathological changes are occurring in the abdomen is immediate operation, with removal of the offending organ. It is perhaps true that some of these patients would recover without operative procedures and that those cases which would require operation can by conservative treatment during the initial hours of the infection be differentiated and then operated on This is true to a certain extent, but by this treatment a certain proportion of cases will come to operation at a time when the appendix is gangrenous or general peritonitis exists. If all were operated on at an early stage such patients would have stood a better chance of recovery This is particularly true in the case of children whose disease is so often more advanced than the symptoms and physical signs would lead one to suppose In these, at any rate, it is never safe to "wait and see."

In those patients who are seen after forty-eight to seventy-two hours from the onset of the illness, there is some discrepancy of opinion about the line of treatment to be adopted. There are those who would operate on all cases irrespective of the time of onset, on the grounds that there is still the danger of infection progressing. The alternative point of view however is that by this time many adhesions are forming and the separation of these

may liberate infection into the general peritoneal cavity especially as at this time an appendicectomy may be extremely difficult Naturally if the condition of the patient is deteriorating in any way as evidenced by a rising pulse vomiting increasing tenderness or distension operation must be performed at once or when the patient when first seen has signs of general peritonitis or an appendix abscess appropriate operative treatment must be carried out But in cases which appear to be subsiding it is safe to keep the patient at rest on a light diet under careful observation and to administer antibiotics (preferably penicillin and streptomycin).

Drainage following operation for an acute appendix is another factor about which opinion is not dogmatic However in those cases where

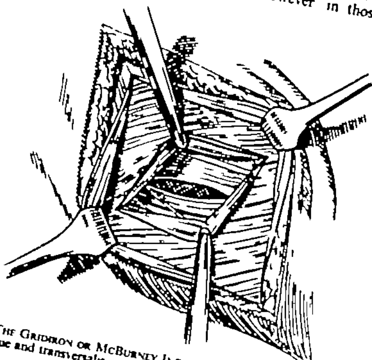


FIG 46 12. THE GRIDIRON OR MCBURNEY INCISION FOR REMOVAL OF THE APPENDIX. The oblique and transversalis muscles are split in the direction of their fibres.

there are many rather œdematous adhesions and in which the appendix, although not perforated, is swollen and perhaps turning gangrenous, and of course in those cases where perforation and general peritonitis exist drainage is indicated and cases so treated are less liable to the complications of residual abscess formation

Appendix Abscess Usually the opening of such an abscess is not a matter of immediate urgency as it is obviously a condition which will occur several days after the onset of the attack and the very fact that an abscess has formed is indicative that the body is getting on top of the infection Where there is resonance over the mass, indicating that it is not yet involving the parietal peritoneum and the signs of toxæmia are not excessive it is best to wait for a day or so until involvement of that layer has commenced because when the abscess is localized there is no danger of spreading the infection to the general peritoneal cavity Where at operation the peritoneum lining the anterior abdominal wall is found not to be involved this must be stripped up towards the abscess until an area where it is involved and

adherent is reached and through this institute drainage. If the appendix can be easily seen, it should be removed, but in other cases its removal should be left for three months.

Appendicectomy One of two incisions is used to expose the appendix The muscle-splitting, gridiron or McBurney incision is used *only* when the diagnosis is certain In all other cases because the McBurney incision allows of such little exposure of the abdominal contents a right paramedian or pararectal incision is employed Because the doubt in the diagnosis is far more common in women than in men on account of the similarity of the symptoms of appendicitis to disease of the reproductive organs these incisions are more frequently used in female subjects.

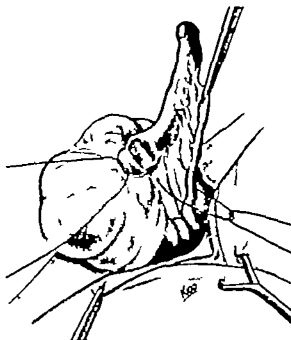


FIG. 46 13 APPENDICECTOMY
A ligature is placed on the meso-appendix, and the base of the appendix crushed and tied.

In the McBurney approach the incision is transverse or oblique about 5 to 6 cm. long, crossing McBurney's spot or a little below it and parallel to the outer end of the inguinal ligament The external oblique is incised in the course of its fibres and the divided segments are held well aside The fibres of the internal oblique and transversalis muscles are separated in the direction of their fibres. If subsequently exposure of the appendix is found to be difficult, a better view is obtained by deliberately carrying the incision across the outer border of the rectus sheath.

After opening the peritoneum, the cæcum is identified and gently withdrawn The anterior longitudinal muscular band leads the way to the appendix, which is freed from adhesions and removed The meso-appendix is first divided after securing its vessels A crushing clamp is applied to the base of the appendix, and when it is removed after a few seconds there is only a thin tube of the serous coat which is ligatured with thread and divided with a carbolized knife just beyond the ligature. To prevent leakage of the

contents before cutting off the appendix, its proximal end is seized with artery forceps A purse string suture is then introduced through the serous and muscular coats of the cæcum around the base of the appendix, which is gently invaginated into the cæcum by a pair of forceps, and the suture tied by this means the stump of the appendix is completely buried. The site of detachment of the meso-appendix or of the position from which the appendix itself has been detached, may require a few sutures in order to ensure a complete peritoneal coating, and thus minimize the risk of subsequent adhesions In females it is always well to explore the right ovary and tube before closing the abdominal wound

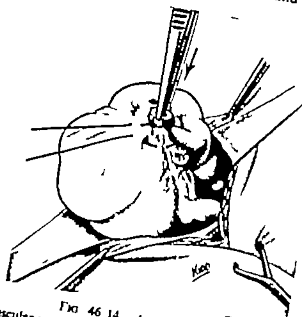


FIG 46 14 APPENDICECTOMY
Seromuscular purse-string suture inserted to invaginate the stump

Where the paramedian incision is used the abdomen is quickly examined and the diagnosis established by feeling the inflamed appendix itself or an adherent mass Adhesions are gently divided keeping to the outside of the appendix, as then damage to its vessels, with consequent severe hæmorrhage is avoided It is well in these acute cases to pack off the rest of the abdominal cavity with towels soaked in hot saline Sometimes the difficulty of mobilizing the appendix is such that a retrograde appendicectomy has to be performed—that is the root is divided and the stump buried, and then the free appendix is removed If an abscess is opened great care must be taken to see that general contamination does not occur by efficient protection of the rest of the abdominal contents by packs. It is best to drain the abscess through a separate stab incision in the iliac fossa rather than by a tube emerging through the main paramedian incision

In these very acute cases care must be taken not to burst the organ in manipulating it or when it is clamped across its base Moreover in tying ligatures on the meso-appendix and its vessels they very easily slip off or cut through on account of the œdema present Care must be taken to try to see that this does not happen or if it does to clamp and ligature immediately that part of the meso-appendix again as otherwise post-operative

hæmorrhage may occur Where the patient has had more than one rigor previous to the operation it is advisable to tie the ileocolic vein as it is probable that such a patient is in danger of pylephlebitis. Especially is this so where actual thrombosis exists.

Post-operative Complications. If the appendix is found to be ruptured and general peritonitis is present, it is advisable to give the patient penicillin (500 000 units) and streptomycin (0 5 g.) twice daily for several days. In spite of this *paralytic ileus* may develop which requires treatment by intra venous fluids and gastric suction

If the temperature and pulse charts, having settled begin to rise again three or four days after operation it is probable that a *residual abscess* may be forming. The most likely places for this are the paracolic region the depths of the pelvis or the subphrenic region The first of these is relatively easy to diagnose, for there will be pain and tenderness in the area of the wound, which itself may show evidence of inflammation and from which pus may be oozing. A pelvic abscess is suggested when diarrhœa supervenes or there is mucus in the stools. Rectal examination reveals a tender mass in front of the rectum which feels hot and may fluctuate A subphrenic abscess may be difficult to diagnose but œdema in the loin is almost diagnostic of this condition and a skiagram may show gas under the diaphragm on the right side with a fluid level The surgical aphorism may be borne in mind "pus somewhere, pus nowhere else, pus under the diaphragm" Once an abscess has localized it must be drained though many now settle down on antibiotic therapy The paracolic type is drained by opening up the wound a sufficient amount, the pelvic type is best drained through the anterior rectal wall or posterior vaginal wall, and the subphrenic type by resecting the twelfth rib and entering Morrison s space from behind.

A grave though nowadays rare complication is *pylephlebitis* or *portal pyæmia* which is indicated by a high swinging temperature and pulse, rigors and pain on the liver it is caused by septic emboli from the appendix bed lodging in the liver An immediate second operation with ligature of the superior mesenteric vein or its branches above the site of the clot is advisable

Another complication that may occur following the removal of an acutely inflamed appendix is *obstructive vomiting* coming on about a week after the operation. It is caused by the flakes of lymph laid down as a protective phenomenon producing adherence between neighbouring loops of bowel with resulting kinking. A second operation may be necessary to relieve this kink.

Late complications are obstruction caused by bands or adhesions which may require operative interference and the formation of a chronic sinus, or even a fæcal fistula, in those cases where an abscess has not been dealt with efficiently and where suppuration of the wound has occurred associated with drainage of an abscess

Intussusception of the Appendix. In this rare condition the appendix is herniated into the cæcum Children are those affected and the symptoms and signs suggest acute appendicitis. The condition is invariably associated with mesenteric adenitis and an increase in the lymphoid tissue of the appendix and terminal ileum Treatment consists of reduction of the intussusception and appendicectomy where possible (Fig. 46 15) Sometimes it is necessary to do a partial resection of the cæcum.

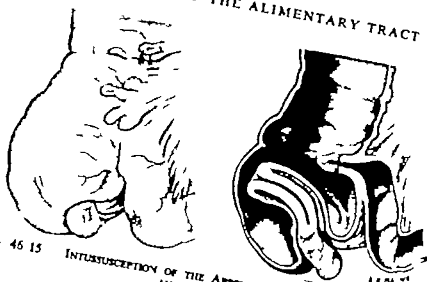


Fig 46 15 Intussusception of the Appendix, showing External Aspect and on Section.

Tumours of the Small Intestine and Appendix

Innocent Neoplasms. These are all unusual but the following occur *Adenoma* is commonly single and usually pedunculated. It may initiate an intussusception or give rise to painless melæna, or it may be responsible for volvulus or kinking of the bowel Submucous *leiomyoma* or *lipoma*



Fig. 46 16 Lipoma of the Jejunum which caused an Intussusception

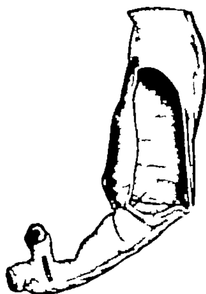


Fig. 46 17 Carcinoma of the Terminal Ileum just Proximal to a Small Meckel's Diverticulum.

occur as do *fibroma* and *hæmangioma* (the last frequently giving rise to hæmorrhage) Symptoms are caused by ulceration or obstruction and treatment consists in excision of the segment of gut concerned or of the tumour itself

Sarcoma of the Intestine. This is rare It may involve the ileum or cæcum and give rise to a localized tumour or diffuse infiltration Obstruction may ensue or considerable peritoneal irritation result in an abundant blood stained exudate which leads to abdominal distension, and may be recognized as due to a new growth on tapping. Treatment consists in removal of the affected coil of gut if the disease has not progressed too far

Carcinoma of the Intestine. This is also an uncommon condition and represents only 0 5 per cent. of all carcinomata of the gastro-intestinal tract from the cardiac end of the stomach down to and including the rectum These tumours are usually situated in the duodenum or jejunum and may develop either as a secondary change in a papilloma or as an adenocarcinoma arising from a solitary adenoma In the past these tumours were rarely diagnosed except at operation for some urgent symptom but to-day with the use of modern X ray equipment more cases are diagnosed prior to operation The growth is commonly annular and gives rise to colicky pain occult blood may be found in the stools. Anæmia is often very marked when the patient comes under the observation of the surgeon On the other hand metastases are unusual at this stage because obstructive symptoms occur early

Primary *adenocarcinoma of the appendix* is also known and sometimes presents as an acute emergency Its natural history is like that of other malignant growths of the large bowel Secondary carcinomatous deposits may also occur in the small intestine.

Chromaffinoma (*Carcinoid Tumour*). Tumours arising from the chromaffin or argentaffin cells of the submucosa of the bowel occur in the ileum and



Fig. 46 18. Low-power Drawing of a Section through the Tip of an Appendix, showing how a Chromaffinoma Fills the Lumen.



Fig 46 19 High-power Drawing of a Chromaffinoma of the Appendix, showing the Small Cells arranged in Masses.

more often in the appendix. In the former they tend to be multiple in the latter almost always solitary and situated at the tip of that organ, where they form a pale yellow bulbous swelling. Occasionally they may determine an attack of acute appendicular obstruction but usually they are discovered after removal or even only on microscopic examination In common with

chromaffinomas elsewhere they secrete serotonin which may be identified in the urine A syndrome is described consisting of attacks of flushing associated with pulmonary stenosis Although these tumours must be considered malignant they rarely metastasize and cause this syndrome. Appendicectomy or resection of ileum is therefore the correct treatment.

INTESTINAL OBSTRUCTION

Intestinal obstruction occurs when the normal onward passage of intestinal contents is prevented and the cause usually falls into one of three large groups (*a*) simple mechanical obstruction (*b*) paralysis of the bowel wall or (*c*) strangulation, *i e* obstruction of the blood supply to the bowel. The term *ileus* has by long usage become synonymous with intestinal obstruction, but in fact this word is derived from the Greek and means to roll or twist and is presumably synonymous with colic. The signs and symptoms of intestinal obstruction are closely related to the level of the lesion in the bowel high small bowel obstruction producing early and severe vomiting and dehydration, while obstruction in the colon may produce only a gradual distension of the abdomen so that vomiting may not occur for forty-eight hours or more

Acute Intestinal Obstruction

General Considerations. The mortality of intestinal obstruction, no matter what the cause has in the past been high and in the last edition of this text book was quoted as being in the neighbourhood of 40 per cent. However the realization that adequate aspiration of the bowel contents and replacement of body fluid by intravenous infusion were important has reduced this figure now to somewhere between 15 and 20 per cent High small bowel obstruction still carries a much poorer prognosis than a lesion in the large bowel although the former is more likely to be diagnosed early

There are a great many classifications of intestinal obstruction for this reason none is completely satisfactory It is important to distinguish the mechanical from the paralytic variety of obstruction since the clinical picture and treatment of the two are totally different, but it should be remembered that paralytic ileus as it is called may be the sequel to a mechanical obstruction

The age of the patient often indicates the type of intestinal obstruction which may be encountered In the newborn malrotation, meconium ileus and duodenal atresia or stenosis are likely causes In young adults the obstructing lesion is usually a band or adhesion. In middle age strangulation in a hernial sac becomes progressively more common and in the older age groups obstruction due to cancer of the colon is more often seen.

Simple Occlusion of Bowel. Simple obstruction of the bowel may be brought about by pressure from without due to adhesions bands or masses disease in the bowel wall such as atresia stenosis regional ileitis and tumours and strictures or by masses which occlude the lumen such as swallowed foreign bodies, gall stones polyps and tumours As a result of obstruction the bowel proximally becomes distended and filled with fluid and gas distal to the obstruction the bowel is collapsed and empty The fluid which accumulates above the obstruction is at first mainly made up of intestinal juices

and bile and vomiting, when it occurs is therefore pale in colour and bile stained If the obstruction remains unrelieved the colour of the fluid changes to brown and eventually almost to black due to changes in the intestinal flora the presence of blood and the out pouring of further fluid The vomiting in unrelieved intestinal obstruction is usually described as "fæcal" but this does not imply that it contains fæces but merely that it resembles them in colour and is offensive in odour Fæcal vomiting is a late sign of obstruction and of poor prognosis

Pathological Changes The phenomena which accompany an intestinal obstruction have been the subject of much study and because of them treatment is now more rational. The physiological changes are dependent in degree upon the level of the obstruction When this occurs just below the ampulla of Vater the body is denied some eight litres of fluid per day in the average adult since at this level all the gastric, pancreatic and salivary juices, together with the bile, are lost. With obstructions at lower levels the loss of water and electrolytes is proportionately less and the surface remaining for absorption consequently greater The loss of water and electrolytes in intestinal obstruction leads to a fall in plasma volume and a reduced urinary output. The urine contains less sodium chloride and the hæmatocrit reveals a concentration of the red cells. The depletion of water and sodium and chloride ions from the extracellular fluid leads to their decrease in the interstitial and intracellular fluid compartments of the body also, and when the obstruction has remained unrelieved for some time, there may be a significant fall in the level of potassium This will be revealed by the hypotonicity of the muscles and changes in the electrocardiograph, as described in Chapter 5

In addition to loss of fluid and electrolytes from the body there is also the absorption of toxins from the distended bowel loops The nature of these toxins has still to be clearly defined but it would appear that they are in part responsible for the fall in blood pressure and liver damage

Intestinal Strangulation

Strangulation refers to the obstruction of the blood supply to a loop of bowel which is usually accompanied by mechanical obstruction of the bowel lumen. It can also occur when, due to embolus or thrombosis, the blood supply to the bowel is cut off Strangulation is commonest in a hernial sac, but bands, intussusception, volvulus or secondary spread of malignant disease, can produce strangulation by pressing on the blood vessels.

When pressure is exerted on the mesentery of the bowel the veins are the first to be obstructed and the bowel appears dusky and cyanotic. Œdema leads to swelling and in time the arteries to the bowel are also occluded. The bowel then becomes black, the mucosa ulcerates and the peritoneal surface loses its sheen Organisms proliferate in the warm dead tissue and the wet, gangrenous bowel breaks down to infect the hernial sac or general peritoneal cavity

With a short loop of strangulated bowel there are few signs and symptoms of toxæmia, the predominant clinical picture being one of intestinal obstruction. Death occurs due to the peritonitis which follows perforation of the bowel. With the strangulation of long lengths of bowel there is a marked toxæmia which is probably due to three factors the release of toxic products from the decomposing tissue, histamine and the production of exo- and

endo-toxins from the bacteria which multiply in the strangulated and gangrenous bowel.

Signs and Symptoms. *Pain* This is the first symptom It is severe, abrupt in onset and usually centred about the umbilicus. It is colicky in character and sudden waves of violent pain are superimposed on a dull ache.

Vomiting This is an invariable accompaniment of obstruction, occurring early when the obstruction is high in the small bowel At first the vomit contains altered food but it soon becomes bile stained and is later effortless in production and offensive and brownish yellow in colour

Absolute Constipation This is always present and is proved by the giving of two enemas The second produces no fæcal result and the fluid has to be syphoned away

Distension This is usually seen and in the presence of large bowel obstruction is usually noticed to be peripheral in distribution filling the flanks in the first place On the other hand small bowel obstruction typically causes a central type of distension but such distinctions should not be relied upon Peristalsis is increased and a stethoscope should always be used on the abdomen when obstruction is suspected In the later stages, paralytic ileus may set in and instead of the noisy tempestuous gurgling, almost complete silence is found with the occasional tinkle of fluid moving beneath large volumes of gas in distended loops of bowel.

The general signs of dehydration will appear with the production of a dry tongue reduced and concentrated urinary output and pinched features with sunken eyes and inelastic skin The blood pressure and pulse rate are not much altered before the late stages of obstruction and the temperature is usually normal or subnormal the white blood cell count is unchanged.

Special Signs Palpation of the hernial orifices may reveal an obstructed or strangulated hernia even although the patient does not know that he has a rupture In the abdomen palpation may reveal a tumour mass, the sausage-shaped swelling of an intussusception or the tympanitic outline of volvulus of the colon A diagnostic skiagram is always performed in suspected intestinal obstruction preferably with the patient in the erect position The film may reveal loops of small bowel distended with gas with multiple fluid levels or in certain circumstances, may point to the actual level of the obstruction as with duodenal stenosis in the newborn

Treatment. The three most important things in treatment are to aspirate the bowel contents, replace the fluid loss by intravenous infusion and relieve the obstruction

Gastro-intestinal Suction The aspiration of fluid from a patient with intestinal obstruction serves not only to remove fluid which might contain toxic substances but also to relieve vomiting and reduce the distension of the bowel and abdomen In its simplest form a Ryle's or Levine's tube is passed through the nose into the stomach and the contents of that organ are aspirated either by syringe every hour or by some apparatus for continuous suction such as a low pressure electric pump A modification of this tube is the Miller Abbott tube which has a double lumen There is a distensible rubber balloon near the tip of the tube which can be inflated after it has been passed into the duodenum *via* the nose The peristaltic action of the bowel then carries it on as far as the intestinal obstruction making it possible to aspirate the whole proximal loop of bowel The only difficulty encountered is that of persuading the tube to pass the pylorus

and many modifications have been introduced to achieve this end such as the Cantor tube which has a mercury loaded tip Although the small bowel is some twenty-two feet in length when examined in the dissecting room in life it may be very much shorter due to its tonicity and a seven foot Miller Abbott tube may present at the anus

Intravenous Infusion The replacement of the electrolytes and water lost by the patient, either by vomiting or aspiration of the bowel contents is essential. The method of calculating how much saline and how much water will be required is laid out in Chapter 5 but it is always safe to start by infusing half normal saline and then discovering by means of the urinary output and its chloride content together with laboratory estimations of



FIG. 46 20. INTESTINAL OBSTRUCTION SHOWING MULTIPLE FLUID LEVELS IN THE SMALL BOWEL.

serum sodium, chloride and potassium, what are the further requirements of the patient. A fluid balance chart must be drawn up showing all the losses by mouth tube or other route, including an assessment of the water lost in the perspiration and breath. It is then possible to calculate how much fluid is required each day to put the patient into balance The presence of a moist tongue and a normal output of urine containing adequate chlorides is a sure sign that this balance has been achieved.

Operation for Relief of Obstruction The operation is designed to deal as directly as possible with the obstruction and if there is an irreducible hernia this will be explored in the first place Where obstruction has occurred in the small bowel and the site is not known, a right paramedian incision is generally preferred since it gives good access to all quadrants of the peritoneal

cavity Where it is impossible to relieve the obstruction, a by-pass operation may be carried out. Special techniques are required for specialized forms of obstruction, as described below

Special Forms of Obstruction

Paralytic Ileus. In this condition there is intestinal obstruction because the bowel wall is paralysed usually because it is bathed in pus due to generalized peritonitis. However mechanical obstruction may give place to paralytic obstruction if left unrelieved and the possibility of a mechanical obstruction being present should always be suspected in the first place. Diagnosis of paralytic ileus is made in the presence of vomiting, absolute constipation and a silent abdomen on auscultation. In the absence of any mechanical obstruction the condition is treated as described above but small doses of morphine (10 mg. or ⅙ gr) are helpful as they produce mild euphoria in the patient and may even stimulate peristalsis.

Intussusception. This is typically seen in over weight, greedy male babies at about the time of weaning. The baby suddenly screams and draws up his legs. He goes pale and may vomit and the napkin may be stained with blood and mucus, a mixture which has been likened to red currant jelly The condition is due to telescoping of the lower ileum upon itself the

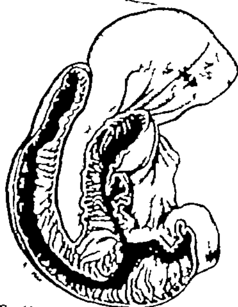


Fig. 46 21 Intussusception (Royal College of Surgeons Museum)

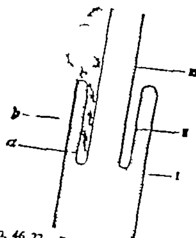


Fig. 46 22. Diagram of Intussusception.
a, Intussusceptum *b* Intussuscipiens I ensheathing layer II, returning layer III entering layer

intussuscepted bowel being then carried on by peristalsis into the cæcum and colon The outer layer of colon or *intussuscipiens* thus contains two layers of small bowel, the entering and returning layers, called the *intussusceptum* It is the combination of intussuscipiens and intussusceptum which constitutes an intussusception.

Palpation of the abdomen during an attack reveals a sausage-shaped mass in the line of the colon while a finger inserted per rectum reveals absence of fæces and a little tell tale blood The condition is treated by the giving

of parenteral fluid and early operation at which the intussusception is milked back. In no circumstances should the bowel be pulled out the intussusception should be reduced by gentle squeezing of the distal mass which returns the incarcerated small bowel like tooth paste from a tube. Rarely, it is irreducible, and on these occasions resection or lateral anastomosis must be undertaken although carrying a much higher mortality Intus-

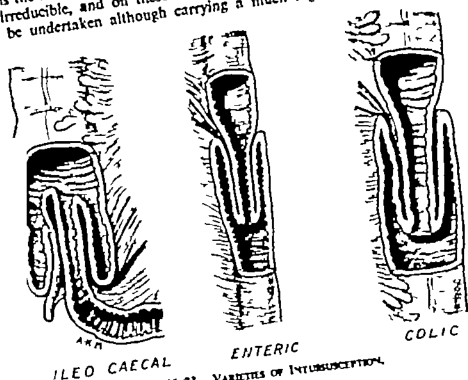


FIG 46 23 VARIETIES OF INTUSSUSCEPTION.

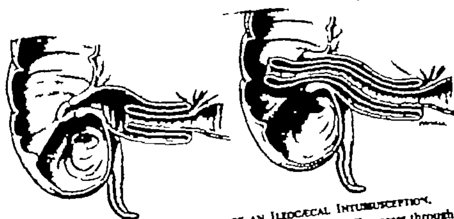


FIG. 46 24 THE FORMATION OF AN ILEOCÆCAL INTUSSUSCEPTION. An enteric intussusception is first formed, and this gradually passes through the ileocæcal valve.

susception diagnosed in the first twenty-four hours offers an excellent prognosis if treated by early operation

In some clinics reduction is attempted by means of a barium enema. The barium is administered and its progress watched on the X ray screen The intussusception is readily reduced as far as the cæcum here it often sticks for a time A sudden "flooding" of the small intestine indicates

that reduction has been achieved. If unsuccessful, operation should be done forthwith.

Volvulus. This is the twisting of a loop of bowel together with its mesentery so that the latter with the blood vessels carried in it is occluded. It occurs under well-defined conditions. In the newborn it is associated with an abnormal bowel which is the site of malrotation. In adults it typically occurs in the small bowel as a result of the presence of adhesions or bands. *In older patients it is usually found in a redundant loop of sigmoid colon.* Volvulus of the bowel demands laparotomy at the earliest possible moment, time only being allowed for aspirating the upper gastro-intestinal tract with a Ryle's tube and the setting up of an intravenous infusion to combat the dehydration. In the case of volvulus of the sigmoid colon it is occasionally possible to pass a rubber tube of wide calibre through a sigmoidoscope and deflate the twisted loop when spontaneous reduction may occur. Failing this, laparotomy is no less urgent than in the other varieties of volvulus.

Gall-Stone Ileus. This condition is typically seen in elderly females who have suffered in the past from gall-bladder dyspepsia. The gall-stone typically impacts in the lower ileum about two or three feet from the ileo-cæcal valve and may be seen on a skiagram. Such patients are usually poor operative risks but the relief of obstruction is relatively simple since it is only necessary to milk the stone back into a wider part of the bowel *from where it can be removed through an incision.* This incision is best made in the length of the bowel and then closed transversely so that no narrowing results.

Mesenteric Thrombosis and Embolism. Embolism or thrombosis of the vessels leading to the gut produce essentially the same picture. The superior mesenteric artery may be blocked by a clot or atherosclerosis and as a result the patient is suddenly prostrated by abdominal pain and colic associated with a precipitate fall in the blood pressure and all the signs of acute intestinal obstruction. Often a little blood is passed per rectum at the same time as the onset of the pain and, if a large segment of bowel is involved, death occurs rapidly. Treatment should, in the first place, be conservative. Rapid transfusion of saline and whole blood is given together with heparinization to prevent further blood clotting. The gastro-intestinal tract is aspirated *via* a nasal tube and antibiotics are given in full doses. If the patient's condition does not improve within a few hours, laparotomy is undertaken, but the heroic removal of large lengths of bowel is not usually attended with success.

Chronic Intestinal Obstruction

Chronic obstruction tends to affect the large bowel more than the small. While the causes, as with the acute variety, may be extrinsic or intrinsic, the latter are the more usual. *Fæcal impaction* in the aged is common but so also is malignant disease and this must always be excluded before a diagnosis of chronic constipation is made. Other causes, such as diverticulitis are dealt with in Chapter 48.

Chapter 47

THE LIVER, BILIARY TRACT, PANCREAS AND SPLEEN

THE LIVER

Displacements. These are not common since the organ is well supported both by ligaments and attachments to deep structures. It is possible for the liver to sink and thus *hepatoptosis* becomes an element in the syndrome known as Glénard s disease. An enlarged liver may manifest somewhat similar phenomena but dullness is then found over the normal hepatic area in hepatoptosis the normal site is resonant

Reidel's lobe is the name applied to a linguiform enlargement of the right lobe, which projects downwards into the loin and can be mistaken for a floating kidney It may be associated with an enlarged gall-bladder probably containing stones, which is covered by the projection. The lobe usually has a broad base of attachment to the liver or may be almost severed from it Its mobility is then considerable and may be independent of the liver A little care in examination should enable the surgeon to differentiate between this condition and a floating kidney if the patient be turned on the left side, the examining hand can be insinuated between the lobe and the kidney Treatment is not required except for the condition of the gall bladder

Rupture of the Liver Rupture results from injuries such as blows, kicks, or crushes, or it may be torn by the broken end of a rib Penetrating injuries also occur as from sword or dagger thrusts and the organ may be involved in a gunshot wound The resulting lesion varies considerably the gland may be merely torn or contused from a non penetrating blow or freely incised by a sharp-cutting implement in which case some of the larger venous trunks are likely to be divided a bullet sometimes produces almost total disorganization. The amount of injury depends, to some extent, on the condition of the organ if it is firm and sclerosed it may receive little damage from a blow which would otherwise harm it considerably while if it is enlarged and fatty it is readily torn.

Symptoms The chief of these are shock, which though often not very excessive, may be of the severest degree pain and tenderness in the right hypochondrium a rising pulse-rate, pallor and air hunger The degree of shock is, perhaps the most important and upon its severity depends to a large extent the result. Should the capsule remain intact, there is considerable intraglandular ecchymosis and laceration, but no free blood escapes into the peritoneal cavity such a lesion is not unlikely to be followed by an abscess of the liver When the capsule is torn intraperitoneal hæmorrhage and escape of bile are sure to ensue if slight, the patient, though suffering from all the phenomena characteristic of loss of blood, may recover the blood being absorbed and the wound in the liver cicatrizing. This process

is usually attended by a certain amount of jaundice and some vomiting, while the urine is also tinged with bile-pigment Well-marked pyrexia may follow the initial shock and the abdominal wall is held rigid. The blood collects at first in the upper part of the abdomen but gradually extends downwards not uncommonly there is some associated injury of the gut wall through which intestinal bacteria find their way giving rise to a localized or general peritonitis In the more severe lesions, where perhaps the left lobe is entirely torn off or a portion hopelessly contused, death from hæmorrhage is almost certain to ensue in a very short time

Diagnosis The diagnosis of hepatic rupture turns mainly on the history of the accident the situation of the blow and the resulting symptoms Evidences of intraperitoneal bleeding, associated with pain in the right side, are extremely suggestive Tenderness is often present in the right iliac fossa where the peritoneum is irritated by the blood passing along the paracolic gutter The abdomen is frequently slightly distended and on auscultation the peristaltic sounds are found to be much reduced.



Fig. 47 1 The Left Hand is Inserted and the Superior Surface of the Liver Rotated Downwards.

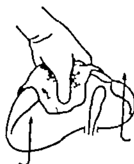


Fig. 47 2. A Piece of Gauze held in the Hand will often Facilitate the Exposure of the Inferior Surface.

Treatment In the more simple cases this consists merely in careful expectancy the surgeon holding himself in readiness to operate should any untoward symptoms supervene The patient is kept quietly in bed on a fluid diet. In the more serious cases where the diagnosis of ruptured liver is tolerably certain an exploratory laparotomy employing a right paramedian incision should be undertaken and an attempt made to deal with the wound. Quite a number of wounds occur on the under surface of the liver and it is most important that this surface should be explored carefully The surgeon's left hand is inserted into the abdomen and the liver grasped and gently rotated upwards until the inferior surface is completely exposed Where by virtue of the position of the external wound it is thought that the damage is on the superior surface a transpleural approach is probably the best as it is difficult to deal with a rupture in this position through an abdominal incision save by packing it. Outlying ragged portions of the gland may be totally removed preferably by diathermy though it may be necessary to pack the wound with gauze in order to effect hæmostasis. Clean linear cuts may be sutured with silk but there is considerable difficulty in preventing the stitches from tearing out of the friable hepatic tissue it is wise to insert all the stitches first taking up a wide margin

of the gland substance before attempting to tie any The wound is then carefully closed by the fingers and the sutures slowly and gently tightened A blood transfusion is given while the operation is in progress and this has considerably reduced the mortality in these cases Very shallow wounds which it is impossible to stitch or plug satisfactorily may be seared with the cautery so as to stop bleeding, a gauze drain is placed over them and brought out of the external wound

Liver Abscess

There are numbers of causes of abscesses or cysts of the liver The most usual are due to pyogenic infection amœbiasis actinomycosis or hydatid disease.

Multiple Abscesses. The organisms may be blood borne or infective emboli may be carried to the organ either by the hepatic artery or the portal vein Cases of the former are rare and are associated with a generalized septicæmia.

Infected emboli may spread up the portal vein in cases where thrombosis accompanies such conditions as acute appendicitis, thrombosed hæmorrhoids, typhoid fever or infection at the umbilicus in babies. The abscesses are acute (suppurative pylephlebitis) vary in size and are scattered throughout the liver substance Usually the infection is a mixed one of staphylococcus and *Esch coli*

Following an operation or recovering from some septic condition, the patient, instead of getting better becomes more ill The temperature and pulse rise again there are rigors and night sweats and the patient becomes toxic and rapidly wastes. Vomiting may be complained of On examination the patient is not usually jaundiced but of a very muddy colour The abdomen is often distended and a painful liver edge is palpable A leucocyte count will confirm the fact that a suppurative process is present

Diagnosis is often difficult and the condition must be distinguished from subphrenic abscess, in which condition the diaphragm will be raised and inactive.

Suppurative Cholangitis. This is also a cause of multiple abscesses of the liver It consists of an inflammatory affection of the biliary duct and passages, and results from the spread of organisms from the intestine, or occasionally from the gall bladder after an operation. The biliary ducts in the liver become enormously dilated and filled with a mixture of bile and pus which closely resembles yellow ochre. It is accompanied by pain over the organ and the general phenomena of pyrexia but rigors are not present The patient is not usually jaundiced but bile may be found in the urine. Duodenal intubation may enable the infecting organism to be isolated and effective specific therapy given Otherwise, the treatment consists of thoroughly exploring and draining the biliary passages at operation. The common bile duct should be well washed out and a T-tube inserted for a number of months. Repeated checks are made on the infecting organism during this time (See infective cholangitis, p 150)

Solitary Abscess of the Liver This usually occurs in men who have travelled or lived in the tropics and is very generally a sequel of amœbic dysentery Suppurative infection of the appendix or gall-bladder may lead to the development of multiple or pyæmic abscesses of the liver but not often to the large solitary abscess. The cavity of an amœbic abscess is

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FIG. 47 1 THE LEFT HAND IS INSERTED AND THE SUPERIOR SURFACE OF THE LIVER ROTATED DOWNWARDS.



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Actinomycosis. Involvement of the liver by actinomycosis is usually secondary to an affection of the alimentary canal particularly the appendix or transverse colon or may be due to a direct spread of the infection The liver is enlarged, and may be covered with adhesions On section the affected area presents a trabeculated honeycombed appearance, which has been compared to a sponge soaked in pus There is much fibrosis around and the trabeculæ are markedly fibrous. The pus contains the characteristic granules of the fungus The clinical history is that of an hepatic abscess and the prognosis is bad. Treatment is as for the disease elsewhere.

Gumma. Gummata may develop in both inherited and acquired syphilis, and are of sufficient size to need careful diagnosis from growths which develop in the liver They are single or multiple and occur in the form of rounded masses, which sometimes caseate, and may be surrounded by much fibrous tissue. Absorption is followed by considerable cicatrization which leads to deformity The diagnosis from secondary carcinoma is not always easy The history of the patient must be carefully considered and the Wassermann reaction tested

Hydatid Cysts. These occur in the liver more frequently than in any other part of the body These cysts are caused by the development within the body of the scolex stage of *Tænia echinococcus* which is a small tapeworm less than half-an-inch in length. These worms occur in large numbers and may inhabit the intestinal canal of dogs. *Tænia echinococcus* consists of four segments, the posterior one being larger than the whole of the rest of the worm and containing genital organs. When mature this last segment becomes filled with ova some 500 or so in number which are discharged, and these find their way into the human stomach from handling the dog, or though probably less commonly by the medium of water or uncooked vegetables, such as watercress, which have been contaminated with the dog s excreta The process of digestion sets the embryo free, and by means of a crown of little hooks which it possesses as well as four suckers it is enabled to bore its way through the walls of the stomach. It travels thence by the portal vein to the liver where it may settle down, or less frequently to the lung or some other part of the body where it becomes encysted A sac forms which produces a localized painless enlargement of the liver the cysts varying in size from a small marble to a child's head the outline is well defined if superficial but not so if placed deeply the cavity is usually filled with fluid and daughter-cysts. Fluctuation may be distinguished and a hydatid fremitus or thrill (arising from the concussion of the contained daughter-cysts) may be elicited on palpation. The diagnosis is easily made if the cysts projects from the lower border but when deeply embedded in the organ it may be exceedingly difficult The tumour can only be distinguished with certainty from carcinoma or syphilis by the use of the Casoni s test in which a local reaction follows the injection of some hydatid fluid under the skin or the complement fixation test, using hydatid fluid obtained from sheep as antigen The character of the fluid withdrawn from a hydatid cyst is also conclusive, as it is of low specific gravity slightly opalescent, with no albumen and a trace of salt the presence of scolices or booklets is the pathognomonic feature

Terminations The cyst may remain latent and innocuous its wall may become calcified or it may actually dry up and form a mass somewhat like wet mortar owing to the death of the organism or it may burst and be

evacuated in different directions with or without suppuration Thus it may open externally through the abdominal parietes or into the peritoneal cavity causing fatal shock and in many cases peritonitis or into the stomach or intestines, spontaneous cure usually resulting or it may penetrate the diaphragm and the contents be expectorated or set free in the pleural cavity causing a rapidly fatal pleurisy It has been known to open into the pericardium, or even into the hepatic veins the contents then being impacted in the right auricle in both cases immediate death resulted

Treatment The best plan of dealing with a hydatid cyst is to lay it open either through the anterior abdominal wall or through the chest and diaphragm to empty it of its contents and if possible to enucleate the lining wall or endocyst which is often but loosely connected to the granular ectocyst. This is usually accomplished at one sitting. Similar precautions as to protecting the peritoneum are taken as for an abscess When the surface of the liver is exposed it is advisable to puncture the cyst first with a trocar and cannula so as to reduce the tension within it and then inject some 5 to 10 ml. of commercial formalin the quantity varying with the size of the cyst. This kills the contents in five minutes where granddaughter cysts are not present. It is then incised freely and the loose daughter-cysts removed This is facilitated by flushing out the cavity with sterilized salt solution. The endocyst is removed either by enucleation with the fingers or a blunt dissector or it may be possible to detach it by irrigation, the nozzle of the irrigator being inserted beneath it If enucleation is completely successful, the lesion in the liver may be closed and the abdominal wound sutured in the ordinary way without drainage dependence being placed on the aseptic organization of the blood-clot which fills the cavity in the liver If for any reason this seems undesirable, a gauze packing is introduced into the cavity and healing by granulation is allowed to proceed If however part of the lining wall is left, a drainage tube must also be introduced, and the cavity subsequently irrigated at each dressing.

No attempt should be made to remove the fibrous ectocyst, as it is closely connected with the liver substance and grave hæmorrhage might follow any interference with it.

A suppurating hydatid cyst is dealt with according to the same rules of treatment as hold good for abscess of the liver

Neoplasms of the Liver

Primary Neoplasms. These are rare. *Adenomata* develop as sharply defined masses usually in the right lobe and cause symptoms only by their size and weight. In some cases suitably situated, removal is quite possible. *Angiomata* may be similarly localized but their removal is rarely feasible on account of their size and because they are likely to be multiple *Carcinoma* may be primary and removal practicable. Extension of malignant disease of the gall-bladder to the liver may tempt the surgeon to undertake removal but it is almost certain that when once the disease has spread outside the gall-bladder it has developed in directions other than that which is visible, and removal will be useless. Should segmental excision of the liver be attempted, dissection of the lobe or lobule may be commenced from the portal fissure and from the point of issue of the hepatic veins Branches of the hepatic artery and portal vein should be tied off early in the dissection to reduce hæmorrhage A good exposure is obtained by extending the abdominal

exploratory incision obliquely up into the chest with division of the costal margin.

Secondary Neoplasms. These are very common and follow a carcinoma of the intestinal canal especially of the stomach (Fig. 47 4) or large intestine or may be a sequel of cancer of the ovary uterus, breast or bladder The liver is also involved secondarily in melanotic disease of the skin or retina In all these cases the organ becomes enlarged and its surface irregular due to the projection of nodular masses of growth, which may be umbilicated Pain is not generally a prominent symptom but ascites and jaundice develop in malignant cases from pressure on the portal vein and biliary ducts in the portal fissure and oedema of the legs may be caused by compression of the inferior vena cava

THE GALL BLADDER AND BILIARY TRACT

The gall-bladder is a pear-shaped sac lying under cover of the liver and projecting into the peritoneal cavity Its average length is 6 to 10 cm. and it is normally capable of holding about 30 ml of fluid An *enlarged* gall-

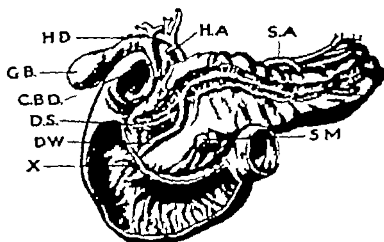


FIG. 47 5 DIAGRAM OF THE BILIARY PASSAGES AND THEIR RELATION TO THE DUODENUM, WHICH HAS BEEN LAID OPEN, AND PANCREAS.

G.B Gall-bladder H A hepatic artery H D., hepatic duct C B D., common bile-duct D.S., duct of Santorini D W duct of Wirsung X, opening of common bile-duct and duct of Wirsung in the duodenum S.A., splenic artery S.M., superior mesenteric vessels.

bladder projects downwards and towards the umbilicus, constituting a rounded swelling which moves with respiration and is almost always in close relation with the anterior abdominal wall It is mobile from side to side and may occasionally attain enormous dimensions. It is attached to the liver by reflections of the peritoneum which vary *somewhat in their* insertion as a rule about a fifth of the circumference of the gall bladder is in contact with the liver The attachment is loose, and when once the right layer has been reached it is easy to strip the gall bladder from the liver *The cystic artery reaches it at some distance from the fundus*

In a few cases the gall bladder has a complete peritoneal investment swinging loose from the liver on a mesentery and on occasion serious colic may develop apparently from this lax attachment *Torsion* of such a gall-bladder may lead to gangrene The treatment is immediate cholecystectomy

The *cystic duct* is about 1 cm in length and is possessed of the spiral valve of Heister. The *hepatic duct* is 5 cm in length and is formed by the junction of the right and left ducts which issue from the liver at the porta hepatis and unite together at a very obtuse angle. The duct passes down



Fig. 47 6. Gall-stones.
Note the facets on the shadows, also their dense periphery and less opaque centres, due to the deposition of lime salts on the cholesterin gall-stones.



Fig. 47 7. Normal Cholecystogram (Oral Method)
The gall-bladder fills normally and no gall-stones are present. The normal common bile duct is also seen.

with the hepatic artery and a little above the upper border of the first part of the duodenum is joined at a very acute angle by the cystic duct The *common bile-duct* is about 8 cm. in length and takes a No 7 catheter 2 cm or more of it is to be found above the duodenal border and then it dips behind the viscus after lying between the inner border of the gut and the head of the pancreas, *it traverses the bowel obliquely* sometimes being distended just before its termination to constitute the ampulla of Vater Into this the duct or ducts of the pancreas also open



1 Intravenous cholangiogram using Biligrafin. The gall-bladder has been removed. The dilated common hepatic and common bile ducts are well shown.



2. Operative cholangiogram by direct injection of 70 per cent. diodone into the common bile duct.



3 Post-operative cholangiogram (injection of diodone via the T-tube) showing that a stone is still present at the lower end of the common bile duct.



4 A second post-operative cholangiogram, after removal of the stone.

Fig. 478. Cholangiograms.

The normally functioning gall bladder may be demonstrated radiologically by the injection or ingestion of phenolphthalein or some such substance combined with iodine or bromine (*cholecystography*) The success of the test depends on the dye being excreted by the liver passing into the gall-bladder and being concentrated by that viscus Radio-opaque gall stones will show as a shadow on plain X ray Radio-translucent stones (and papillomata and some carcinomata) will show as filling defects in the shadow cast by the tetrabromphenolphthalein A gall bladder which does not fill must be considered as pathological one which concentrates the dye inadequately or which contracts incompletely (after a fatty meal) may be pathological If radio-opaque gall-stones need to be differentiated from renal calculi a lateral X ray will show their anterior position and intravenous pyelography will demonstrate the position and state of the kidney

Cholangiography The radiological demonstration of the biliary passages can be done by two methods (1) *Intravenous cholangiography* by the intra venous injection of Biligrafin This investigation is of particular value when a stone in the common bile duct causes intermittent obstruction or when the gall-bladder has been removed and demonstration of the biliary passage is required. The dye is excreted by the liver so that, as with cholecystography a useful result depends on a well functioning liver

(2) *Operative cholangiography* by the injection of a suitable radio-opaque fluid directly into the biliary passages 50 per cent diodone is commonly used, in quantities of 20 ml It matters little how it is injected by catheter cannula or needle but the biliary system should be water tight so that the ducts are filled and so that leakage does not obscure the picture All patients undergoing operations involving the biliary passage should be fixed on the operating table on a cassette tunnel so that the X rays can be obtained without disturbing the patient s position The investigation should be repeated to demonstrate that the obstruction to the biliary tract has been removed

Rupture or Perforation of the Gall-Bladder This results from such injuries as blows crushes, kicks, stabs or bullets occasionally it follows ulceration from within as from a large impacted gall-stone. Blood and bile escape into the peritoneal cavity Pure bile is sterile and highly irritating so that it causes acute peritonitis on its own account. A biliary effusion of any size will in any case become infected in a matter of days but if any inflammation of the biliary passages has occurred organisms are sure to be present. Slight jaundice arises from absorption by the peritoneum of bile, which may also be found in the urine A more gradual escape of the secretion will probably lead to the formation of a localized intraperitoneal abscess or collection of fluid associated with jaundice and possibly clay coloured stools In a penetrating wound bile and blood will escape on the surface and septic peritonitis is almost sure to follow The prognosis of cases of perforation due to stone is always bad, since the patient is often stoical and elderly and has probably been accustomed to severe attacks of pain and the change in type may not be recognized until too late.

The immediate symptoms are those of shock and severe pain under the ribs, and this will be succeeded either by acute peritonitis or by the formation of a localized intraperitoneal swelling, together with mild jaundice. When the existence of such a lesion is suspected, exploratory laparotomy must be

undertaken The condition may have been diagnosed as perforated gastric or duodenal ulcer and it is only the character of the exudate that calls attention to the biliary passages. Should only a small injury be found in the gall-bladder it is perfectly feasible to close it by sutures a cigarette drain should however be passed down to the lesion for a few days, so as to provide a means of drainage should leakage occur A more serious rupture necessitates removal of the gall-bladder Should the common bile-duct be entirely divided, the ends should be united by suture but in grave cases, where the gall bladder is undamaged and healthy it may be wiser to close the ends completely and undertake a cholecystenterostomy

Infective Cholangitis. This is a serious affection and in severe cases may lead to a fatal issue It is usually due to the presence of a stone or stones in the common bile-duct or a stricture or from malignant disease but may

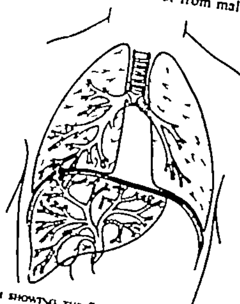


Fig. 47 9 Diagram showing the Site of a Bronchobiliary Fistula.

arise from other causes, *e g* ascarides or hydatid cysts which have escaped into the biliary passages, or it may spread backwards into the liver from a suppurating gall-bladder The general phenomena which follow an attack of biliary colic owing to the attempted or successful passage of a gall-stone are due to this cause hence fever with or without a shivering fit a certain amount of jaundice (which is easily comprehended when one remembers the low pressure at which the bile is secreted), enlargement and tenderness of the liver are to be looked on as the characteristic features of a mild attack Treatment necessarily consists in removal of the cause if possible or failing that in draining the biliary passages. It must not be forgotten that the persistent presence of such a condition may lead not only to serious damage to the liver but also to chronic pancreatitis and also to adhesive peritonitis which may complicate future operative procedures Therefore operation should never be long delayed.

In the more serious type of this affection suppuration extends along the biliary passages in the liver and leads to multiple abscesses a condition already noted If one of these abscesses erodes upwards through the diaphragm, a bronchobiliary fistula may result. The prognosis is very grave

Cholecystitis

Cholecystitis or inflammation of the gall bladder is an infection due to such organisms as the streptococcus staphylococcus *Esch coli* or *B typhosus* which are probably blood borne It is seen most commonly in females of the "fat and forty" variety *although it may occur in males and at all ages* It used to be supposed that the infection spread up the common bile duct to reach the gall bladder but the pathological finding that in early cases the inflammation is confined to other routes, preclude such a supposition It is however possible that in some cases the infection may be lymph-borne from such neighbours as the colon duodenum or appendix

The gall-bladder undergoes pathological changes varying from acute catarrhal to suppurative and phlegmonous, as in inflammation of the appendix but there is the essential difference that in the latter perforation with general peritonitis, is far more common This is due to the fact that the gall-bladder is more able, by virtue of its normal distensibility to withstand increase in the volume of its contents and that its blood supply coming from a fixed point is less likely to be impeded

Acute Cholecystitis. This is almost always associated with gall-stones The patient complains of pain which starts in the region of the umbilicus, and settles in the right hypochondrium There is a feeling of nausea, with vomiting on occasions, associated with a general malaise Pain may be referred to the right shoulder or to just below the right scapula The temperature and pulse are raised and on examination there is a tenderness and a certain amount of rigidity over the gall bladder A sign of value in inflammatory conditions of the gall-bladder is that described by Murphy If gentle pressure is exerted in this region and the patient instructed to take a deep breath the *gall-bladder descends on to the palpating fingers and if inflamed the pain so* produced will cause the patient to catch his breath If there is associated jaundice, there will of course be an absence of pigment in the stools and an increase in the urine.

Medical Treatment The administration of suitable antibiotics should be started at once. Penicillin and streptomycin combined is usually effective and safe Irritation of the peritoneum or actual peritonitis must be treated with the parenteral administration of fluids, nutriment, etc. The attack usually subsides rapidly The patient is forthwith built up for operation supportive therapy including the administration of glucose, calcium and vitamins B C and K.

Operative Treatment All agree that cholecystectomy must be done to avoid the dangerous complications that otherwise ensue. The timing of its removal is a matter of some controversy If the acute attack subsides without complications cholecystectomy can be done within two weeks with about the same degree of safety as cholecystectomy for uncomplicated gall-stones The dissection is carried out in favourable circumstances, but delay adds to the risk of complications such as peritonitis and cholangitis and prolongs *the patient's incapacity* Some surgeons maintain therefore that immediate cholecystectomy is indicated, as with immediate appendicectomy in appendicitis, and that it is easier to operate before adhesions form and complications supervene. Most surgeons compromise by delaying operation on those cases which respond to medical treatment, and operating early on those cases in whom the inflammation does not rapidly subside.

Suppurative and gangrenous cholecystitis are, as has been mentioned, associated with previous trouble in the gall-bladder A stone in a previously infected viscus may become impacted in the cystic duct and a free outlet to the secretions of the gall-bladder prevented Suppuration steadily ensues, and the fibrosed gall bladder wall becomes thick and oedematous. This suppuration perhaps associated with the ulcerating and pressure effect of a stone, may give rise to a spreading gangrene with ultimate perforation and general peritonitis or if adhesions have formed sufficient to localize the infection a subphrenic abscess. It is such cases which require immediate operative treatment.

Chronic Cholecystitis. This is the result of attacks of acute or subacute inflammation and is often associated with gall-stones In most cases the viscus is thickened and contracted and the neighbouring liver shows signs of chronic hepatitis. But where a single stone, usually a cholesterol solitaire, has obliterated the lumen of the cystic duct before gross inflammation has set in the gall-bladder will be found distended with its own secretion of mucus, so that it may become palpable below the costal margin. If perhaps the occlusion is not absolutely complete some bile regurgitates and secondary mixed stones may form in the gall bladder Around the viscus adhesions form, binding it down to the duodenum and pylorus There is no doubt that many of the symptoms complained of by the patient are due to interference with the normal function of these organs.

Symptoms and Signs In general the symptoms and signs are those of cholelithiasis in the absence of acute attacks of colic. Cholecystography will be of help in the diagnosis

Cholesterosis of the Gall-Bladder This condition is rarely associated



FIG. 47 10 CHOLESTEROSIS. MICROSCOPICAL APPEARANCE OF ONE PAPILLARY PROCESS WITH FOAMY CELLS. (× 160)

with symptoms and is noticed either at laparotomy or at post mortem examination It is likely that the gall bladder is able to absorb cholesterol from the bile and in those cases where there is general dysfunction of the metabolism of cholesterol this in the form of esters and neutral fat is

eposited not only in the lining cells of the gall bladder but also in macro-hage cells of the submucous stroma It seems also possible that if the con entration of cholesterol in the bile is reduced a reverse process may take ace and the deposits disappear

It is not the rule to find any evidence of inflammation in the wall of the all-bladder This, of course may occur as an added condition as may so the presence of gall stones These usually, though not always are of e pure cholesterol type and when so occurring are a further manifestation f the cholesterol metabolism dysfunction

A condition known as "strawberry" gall bladder is a result of added fection in a gall bladder already affected with cholesterosis On opening ich a gall bladder the inflamed mucosa studded with points of yellow ive it the appearance from which its name is derived. Where the condition lone exists the gall-bladder will still adequately concentrate tetraiodo-henolphthalein.

Gall-stones

Cholelithiasis. This is the term applied to the presence of gall-stones in the all bladder and biliary passages, occurring most commonly in middle aged omen The stones are of several types The common mixed stones the econdary calculi follow gross infection though they often have a primary alculus as a nucleus. Primary calculi *e g* cholesterol and pigment stones re formed in gall bladders which are disordered rather than inflamed or ppear in association with metabolic disorders such as cholesteræmia and æmolytic jaundice.

Types of Stone. *Mixed* These are formed of a nucleus of bacteria and mucus round which are deposited layers of the calcium salts of bilirubin and biliverdin with a certain amount of cholesterol in the interstices. They are found in a chronically fibrosed gall bladder The stones are faceted where they lie in contact with one another and any number from a few to several hundred may be present Their size, too varies enormously but in one gall-bladder where they are not all of the same dimensions, groups or families of the same size may be recognized presumably laid down during periods of successive infection in the viscus. Occasionally a single stone of this type is found often dumb-bell-shaped where the gall bladder seems to have grasped it round its waist.

Cholesterol A solitary stone composed of pure cholesterin and associated with disorder of cholesterol metabolism or with an alteration of the colloid content of the bile, which maintains the insoluble crystalloid cholest erol in solution. The stone is often situated towards the neck of the gall-bladder with consequent obstruction to the outflow and dilatation of the gall-bladder which is filled with mucus. If infection supervenes and bile manages to pass into the gall bladder mixed stones will also be present and the solitaire may become coated with a brown layer of bile salt. It should be noted that whereas the structure of the mixed stone is of concentric lamellæ, that of the cholesterol stone is of a radiate striæ.

Pigment Stones These are composed of pure pigment and are coal black and shining, with irregular surfaces.

Calcium Carbonate Stones Although these of themselves are extremely rare, it is often found that the outer layer of mixed stones is composed of almost pure calcium carbonate, and it is suggested that this is deposited

when absolute obstruction to the cystic duct exists in the presence of infection Gall-stones formed in the biliary passages rarely contain much cholesterol being formed of bile pigments and calcium salts.

The fact that gall-stones are frequently found unexpectedly on the operating table or in the post mortem room suggests that they may remain quiescent for years and only cause trouble when attempting to escape, or if associated with some inflammatory disturbance Thus the first evidence of the presence even of a large stone may be an attack of acute suppurative cholecystitis and then unless prompt attention is given, diffuse peritonitis results. It is probable that unless biliary colic occurs gall-stones give rise

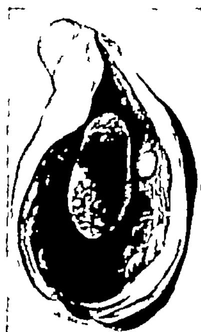


Fig. 47 11 Single Gall stone in Thick-walled Gall-bladder. (*King's College Hospital Museum*)



Fig. 47 12 Multiple Gall-stones in Thin-walled Gall bladder. (*King's College Hospital Museum.*)

to few symptoms of themselves, the dyspepsia and pain being the result of the inflammatory condition of the walls of the gall-bladder with which mixed stones are associated. Adhesions often form between the gall bladder and surrounding tissues and thereby the movements of the pylorus or transverse colon may be hampered. More frequently the gall bladder contains enough fluid to keep its walls distended and then efforts to expel the stones follow giving rise to definite painful symptoms of colic. Sometimes the stones slip back at others they pass on into the cystic or the common bile-duct, and find it impossible to progress further Passage into the intestine is almost always effected by ulceration through the gall bladder wall into the duodenum though stones have been known to pass into the stomach colon and even into the pelvis of the right kidney Sometimes they escape into the general peritoneal cavity and cause peritonitis Cancer may result from the chronic irritation and ulceration set up by a stone pressing on the bladder mucosa

Clinical History The symptoms in a case of cholelithiasis are often

vague and obscure before the onset of typical biliary colic They are essentially due to the inflammation in the gall-bladder rather than to the pressure of stones *per se* The patient is often overweight and usually female For years there has been dyspepsia and flatulence inability to take certain foods particularly fats, with a feeling of nausea and heaviness amounting to pain in the epigastrium. Often there are periodic attacks of subcostal pain which may be referred to the shoulder Sometimes a chronic appendicitis or peptic ulceration is simulated and actual vomiting may add to this resemblance Tenderness in the subcostal region is often elicitated in these cases. The gall bladder is rarely palpable X ray of course, is invaluable. Where the



FIG. 47 13 CHOLECYSTOGRAM SHOWING THE FILLING DEFECTS OF RADIO-TRANSLUCENT CALCULI

cystic duct is patent and the bladder not so damaged as to be able to concentrate the dye, the stones will appear as filling defects In other cases no gall-bladder shadow will be demonstrable and although the presence or absence of stones will not have been confirmed at least a diseased gall-bladder is almost certain. The worst pain is *biliary colic* due to the efforts to expel the stones. This is often of an excruciating character starting suddenly often at night, continuing for a while, and sometimes ceasing as suddenly as it commenced when the stone slips back or passes on the patient may be collapsed owing to its severity but usually she rolls about on the bed or paces the room because rest is impossible Hot water bottles may relieve the pain which radiates from the right hypochondrium shooting over the scapular region and into the back the gall-bladder may be enlarged and tense during the attack. Vomiting usually occurs during or after an attack,

but jaundice only follows when there is obstruction to the common duct by stone or by inflammation or by compression by the distended gall-bladder

Prolonged *impaction* of a stone *in the cystic duct* is characterized by pain, which is more or less persistent but with paroxysmal exacerbations. The gall-bladder may become distended with its own mucoid secretion (*hydrops*) until it attains a considerable size. Jaundice is absent Not uncommonly acute inflammatory phenomena follow (acute suppurative cholecystitis) and thus may lead to ulceration, perforation or gangrene Chronic suppuration leads to the formation of an *empyema* of the gall-bladder

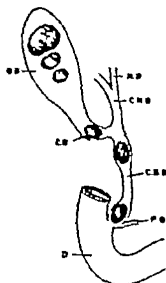


FIG. 47 14 DIAGRAM OF GALL-BLADDER AND BILE DUCTS TO INDICATE THE USUAL SITUATIONS FOR IMPACTION OF GALL-STONES

G.B., Gall-bladder H D., hepatic ducts C.H.D., common hepatic duct C.D cystic duct C.B.D., common bile duct P D., pancreatic duct D., duodenum.

Occasionally a stone becomes lodged at the junction of the cystic and the hepatic ducts, and then the manifestations of obstruction are severe and the pain may be very acute Icterus is intense but the gall-bladder may be empty the liver is certain to be enlarged

The presence of gall-stones *in the common duct* may give rise to symptoms of the most diverse type a small stone may start very severe phenomena whilst a much larger stone may cause less trouble. Frequently *several stones* are present and sometimes they are embedded in a mass of soft " biliary mud " consisting of inspissated bile salts Their location too varies considerably a single stone is perhaps found most frequently in the lower part of the duct while multiple stones involve its whole length. The *symptoms* caused are pain of a paroxysmal character accompanied by vomiting. There may be jaundice sometimes of a severe type occasionally less marked but rarely as persistent as the jaundice due to malignant disease The stone being *more or less movable* acts as a ball-valve at times allowing bile to pass. " In cases of obstruction to the common bile duct by stone the gall bladder seldom distends." This is *Courvoisier's Law* and it holds good in the majority of such cases The converse is equally valid, that obstructive jaundice in the presence of a dilated gall-bladder is rarely due to stone In

malignant disease the obstruction is often absolute and the jaundice is of a more maintained character If the stone is located in the ampulla of Vater it is easy to understand that pancreatic troubles are likely to be associated with the jaundice. In this position it may ulcerate into the duodenum without much difficulty but should a perforation form posteriorly the retroperitoneal cellular tissue becomes involved and a subphrenic abscess may result.

Treatment Where there is no constitutional contra indication the treatment of gall stones is surgical During the attack of biliary colic the pain must be relieved by the administration of heroin or pethidine with heat to the subcostal region, but when the attack is cleared operation is indicated. A diet of ample protein, carbohydrates and vitamins but containing a minimum of cooked fat is recommended

Where jaundice is present operation should be postponed for a few weeks to see whether it will subside, as jaundiced patients bleed more readily and continuous oozing occurs from the incision In these cases preliminary medication with vitamin K and intravenous calcium gluconate is of undoubted value and transfusions may be essential

Operative Treatment When the gall bladder contains stones it should be removed together with the cystic duct (*cholecystectomy*) This must be combined with exploration evacuation and drainage of the common duct (choledochostomy) if the patient has been jaundiced and if stones or sludge are found in the common duct. If there is doubt, the common duct should be explored If it is found to be normal it may be closed (*choledochotomy*).

Occasionally in an ill patient the condition of the gall-bladder presents such difficulties that an easier and quicker operation than cholecystectomy is indicated such as removal of the stones with drainage of the organ (*cholecystostomy*), or removal followed by suture (*cholecystotomy*) Both of these operations, however leave a diseased organ which will be the source of subsequent trouble. Incision of the whole length of the gall bladder with diathermy coagulation of its mucosa is occasionally a valuable compromise measure, but only when the patient has not been jaundiced

A stone in the common bile duct may be removed by exposing and incising the duct (*choledochotomy*) There is but little difficulty in effecting this if the stone is in the upper part above the duodenum with a finger of the left hand in the foramen of Winslow it is localized and steadied and a longitudinal incision through the peritoneum and duct wall permits its removal. Careful packing with gauze swabs is necessary to protect the peritoneum from the flow of bile, which is often considerable The duct is then palpated upwards towards the liver and down to the intestine so as to ascertain if possible, the presence of other calculi. The downward passage of a probe into the intestine makes certain that the papilla is patent. Operative cholangiography (Fig. 47 8) is of value in most cases.

After-drainage A drainage tube is carried down to the site of the incision and maintained for a few days to ensure an exit in case of leakage. In the great majority of cases the calculi in the bile duct are multiple and the symptoms of some duration and gravity the hepatic ducts are then certain to be inflamed and may be considerably dilated sometimes a good deal of grit or bile-mud is present. It is therefore imperative that the biliary passages themselves are also drained (Fig. 47 16). A T-shaped tube, one of the horizontal limbs passing up towards the liver and the other through the papilla of Vater is employed, combining as it does, the merits of upwards and down

wards drainage at the same time allowing bile to flow into the duodenum. Where mud or grit is present, the ducts should be irrigated at the time of insertion of the T tube, followed later by daily irrigations with sterile saline so long as the tube is *in situ* which may occasionally be for months. Further cholangiograms should be taken before removing the T-tube.

If a stone is lodged behind the second part of the duodenum it is often possible to manipulate it upwards and deal with it above the bowel. If this is impracticable the duodenum must be mobilized by dividing the peritoneum on its outer edge then it can be displaced inwards sufficiently to enable the duct and stone to be reached.

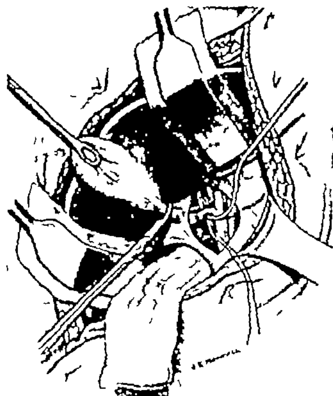


FIG 47 15 CHOLECYSTECTOMY LIGATURE OF THE CYSTIC DUCT

When a stone impacted in the ampulla of Vater cannot be manipulated upwards, the duodenum should be opened on its anterior aspect, the biliary papilla sought out and a longitudinal incision made upwards from this so as to open the ampulla and allow the stone to be removed. The walls of the bile-duct and duodenum are then sutured together thereby determining the formation of a large communication between the two (*internal choledocho-duodenostomy*), which permits of effective drainage of the biliary apparatus and is a most satisfactory procedure.

Operative Technique. It is wise in all operations on the biliary passages to have a cassette tunnel in place, ready for cholangiography should it be required. The incision should be free to give good exposure. A tense distended gall-bladder should be aspirated. Retraction of the stomach and intestines should be by the assistant's left hand and of the liver by a flat retractor guarded by a gauze pack. The types of incision commonly

used are a paramedian Kocher s right subcostal or an almost transverse incision The latter two give a more direct access to the biliary passages and are therefore to be preferred for the fat and difficult patient

Cholecystotomy The trocar puncture in the gall bladder is enlarged by the knife, and the stone or stones removed by forceps scoop or by digital extrusion, and then the opening is closed by sutures which do not encroach on the mucous membrane One or two rows of stitches may be employed according to the condition of the gall bladder wall and it may be wise to strengthen the site of union by an omental graft For *cholecystostomy* a medium-sized drainage-tube without lateral openings is stitched into the

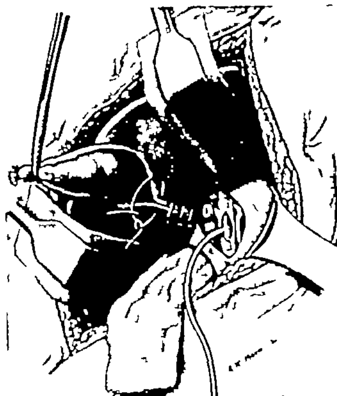


FIG. 47 16. CHOLECYSTECTOMY WITH CHOLEDOCHOSTOMY
The gall-bladder is partially removed and its bed in the liver peritonized. A T-tube has been placed in the common duct.

gall-bladder by catgut sutures, which should last about a week. The gall-bladder is then fixed to the parietal peritoneum and the remainder of the wound closed. The outer end of the tube is passed into a bottle lying by the patient s side, in which the bile collects. When the tube becomes loose the wound is lightly packed with gauze, and for a time the patient s condition is uncomfortable, as the bile escapes into the dressings which must be frequently changed. As, however the wound granulates, it becomes more difficult for the bile to escape externally and more easy for it to follow its natural course hence after two or three weeks the external flow usually ceases and the wound may be allowed to close. Should the escape of bile persist, further operative treatment becomes necessary If the presence of a certain amount of bile in the motions indicates that the common bile duct is free from obstruction the opening in the gall bladder may be completely closed

by sutures after freeing it from adhesions. The absence of bile in the stools, however suggests the presence of some stricture or obstruction in the bile duct if this cannot be dealt with, cholecystenterostomy must be undertaken

Cholecystectomy This is usually not a difficult procedure, and the mortality is small. As soon as the abdomen has been explored the full diagnosis established and the whole biliary system carefully palpated, the cholecystoduodenal fold is cut and the cystic duct dissected Its junction with the common hepatic duct and the common bile duct must be very clearly defined. By doing this step of the operation first in a field of dissection not obscured by blood risks of injuring the common duct are reduced to a minimum. The cystic duct is then secured as near to the common duct as possible so that there is no distortion of the main biliary passages when the ligature is tied and so that no appreciable stump remains (Fig. 47 16). The cystic artery is then clamped, cut and tied. The serous coat is next divided on either side and over the fundus about a centimetre from its reflexion from the liver and a line of cleavage is generally found without difficulty between the capsule of Glisson and the body of the viscus. It is then easy to separate it from the liver If possible the peritoneal coat is drawn together over the gap left by the removal of the gall-bladder The wound is drained, preferably through a separate stab incision

In difficult cases it is sometimes preferable to remove the gall bladder in a retrograde manner beginning at the fundus. The essential points in the operation are not different

Cholecystenterostomy The formation of an artificial communication between the gall bladder and the bowel is required in cases where jaundice persists, owing to absolute stenosis of the common duct. It has also been undertaken for the relief of jaundice due to malignant disease either of the common bile-duct, the head of the pancreas or of the intestine the relief given under the latter circumstances is, of course, only temporary The parts are exposed as described above, the gall-bladder and duodenum are brought into contact and an anastomosis made by simple suturing, the technique being similar to that employed for a lateral anastomosis of the intestine The anastomosis should be as large as possible and is well constructed by cutting off the fundus and suturing the whole circumference of the gall-bladder to a transverse incision in the duodenum.

Tumours of the Gall-Bladder and Biliary Passages. These are usually malignant, and of a columnar-celled type of carcinoma benign tumours are very rare and merely of pathological interest Cancer is comparatively common and is so constantly associated with gall-stones (some authorities state that 90 to 95 per cent. of such cases also have gall-stones) as to suggest that the irritation of the latter may induce the neoplastic formation The disease is about three times as common in women as in men Cancer of the gall-bladder usually starts near the fundus and spreads upwards. The symptoms and signs are usually vague Sometimes there is a swelling in the region of the gall-bladder but usually there is no more than progressive loss of weight and appetite and later on jaundice and ascites. *Primary* cancer of the common bile duct is rarer and may commence at the bile duct papilla or higher up At first it causes jaundice without pain, and sometimes distention of the gall-bladder the jaundice is persistent, gradually increasing in severity

Treatment This is rarely practicable as the disease is usually recognized too late Excision of the gall bladder and if need be of the neighbouring portion of the liver may be practicable in a few cases but is rarely successful For tumours of the common bile duct excision is sometimes possible but recurrence usually follows cholecystenterostomy may relieve the intense jaundice and add to the patient s comfort.

THE PANCREAS

The pancreas is a gland secreting an active digestive juice which passes into the intestine through the duct of Wirsung this traverses the whole length of the gland, and opens with the common bile duct into the ampulla

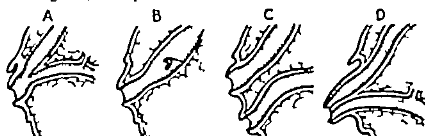


FIG. 47 17 THE VARIOUS WAYS IN WHICH THE COMMON BILE DUCT AND THE DUCT OF WIRSUNG OPEN INTO THE DUODENUM.

A, Normal B, duct of Wirsung opening into common bile-duct C, two separate openings D two openings on a papilla.

of Vater a small accessory duct of Santorini opens into the bowel about an inch higher up There are various abnormal ways in which the common bile-duct and the duct of Wirsung may open into the duodenum (Fig. 47 17)

There are two chief risks associated with pancreatic lesions or operations (*a*) The organ is very freely supplied with blood and it is extremely difficult to ensure hæmostasis. Ligature of the pancreatic tissue causes necrosis and from the necrotic tissue ferments are set free which act injuriously on the tissues around, and predispose to further hæmorrhage Deep stitches and effective tamponade can alone be relied on in this direction (*b*) The leakage of pancreatic juice is a serious danger to the patient in that it is likely to determine necrosis of fat wherever it spreads hence foci of fat necrosis may be found scattered extensively through the omentum and mesentery in all acute pancreatic lesions. Moreover it acts most prejudicially on the peritoneum, and induces either an aseptic peritonitis and intestinal paralysis which may prove fatal or determines an infective peritonitis if bacteria are present.

Wounds of the Pancreas. These are caused by violence applied to the epigastrium and may result from penetrating or non-penetrating injuries. They are usually accompanied by lesions of other viscera, such as the stomach or duodenum and surgeons should remember the necessity of examining this viscus in any traumatic condition in the neighbourhood Deep sutures and tamponade must be used in all cases where solution of continuity has occurred, the latter being needed not only as a hæmostatic agent, but also in order to drain away any leakage of pancreatic fluid

Pancreatic Fistula. Although the majority of cases of pancreatic fistulæ follow trauma from without, a few cases have been known to occur after

accidental injury to the gland during upper abdominal operations, such as resection of the duodenum for carcinoma or excision of a cancer of the common bile-duct. On account of the proteolytic action of the pancreatic enzyme the skin around such a fistula rapidly becomes digested. To prevent this the skin must be covered liberally with aluminium paint or a barrier cream and the secretions sucked away constantly by a suction pump in a sump drain. Most fistulæ will heal if treated along these lines. In cases of failure the fistula is implanted into the jejunum.

Acute Pancreatitis. This is a grave affection involving women more frequently than men. Although its name suggests that its nature is inflammatory, it seems perhaps probable that the changes present in the organ in this condition are essentially vascular in nature. The ætiology of acute pancreatitis is obscure, although the frequent association of the presence of gall-stones in some 60 per cent. of cases is noted by all writers. An endeavour has been made to attribute it to activation of the inactive trypsinogen by a regurgitation of bile along the duct of Wirsung, the regurgitation being due to an impaction of a stone in the region of the papilla of Vater, but it is only rarely that such an impacted stone is actually found. Experimentally it is only when bile is injected into the pancreatic ducts at a pressure sufficient to rupture the alveoli that any change resembling acute pancreatitis occurs.

Some have attributed a spasm of the sphincter of Oddi as instrumental in producing reflux of the bile. However, it has been shown that in a majority of cases the sphincter is proximal to the junction of biliary and pancreatic ducts.

Others believe that the disease is due to a lymphatic or blood-borne infection. The association of acute interstitial pancreatitis with mumps is an example of this phenomenon of blood-borne infection which should probably be considered the cause in a majority of cases.

Obstruction in the pancreatic duct, with stagnation and perhaps activation of the enzymes may be due to such rare conditions as calculi, the presence of a worm, or pressure due to a duodenal diverticulum. Finally the pancreatitis may be initiated by an acute degeneration resulting from interference with the blood supply to the organ, as in arteriosclerosis.

The pancreas rapidly becomes enlarged, œdematous and reddened, hæmorrhage occurring into it and into the tissues around. Liberation of the pancreatic enzymes causes a splitting of the fat in the mesentery and omentum, the retroperitoneal fat, and sometimes in the abdominal wall, with the formation of scattered areas of a granular nature in these positions. At first there is produced a non-infective peritonitis, with resulting dilatation of the intestine and effusion into the peritoneal cavity. This, however, usually becomes infected. Occasionally blood is present in the effusion, this being due either to the proteolytic action of the trypsin on the walls of the blood vessels, with subsequent erosion and bleeding, or to an escape from dilated capillaries and blood-vessels where thrombosis of the superior mesenteric, splenic, or portal veins occurs.

In very severe cases the whole pancreas may slough, become infected with the production of an abscess, whereas in milder cases effusion limited to the lesser sac of peritoneum only may form.

Symptoms. The patient, usually middle aged, is seized with acute abdominal pain localized to the epigastrium and hypochondria, and asso-

ciated with a marked degree of collapse Pain may be complained of in the back of a severe piercing nature although its severity is scarcely as great as that associated with perforated duodenal ulcer or renal or gall-bladder colic. The temperature is subnormal but the pulse much raised and thready and the respirations shallow and increased Cyanosis and a moist clammy skin are usually present while occasionally slight jaundice is observed Persistent vomiting, first of bile-stained material and latterly of intestinal contents, is almost invariable Blueness round the umbilicus discoloration in the loins and at hernial orifices have also been noted

The abdomen is tender in its upper part though rigidity is not extreme, and soon rapid distension ensues with associated constipation Abdominal sounds are variable.

The uncertainty of Loewe s adrenaline test has caused its general abandonment, but a determination of the urinary diastatic index, normally 4–50 will reveal an early rise of anything up to 2,000 The serum amylase will be more constantly elevated Glycosuria or raised blood-sugar and the presence of bile in the urine are variable findings

Differential diagnosis The condition must be distinguished from perforation of a peptic ulcer intestinal obstruction, acute peritonitis acute pericarditis and coronary thrombosis

Treatment Little advantage is to be gained by operating on a case of acute pancreatitis except to drain an abscess or to confirm the diagnosis. The conditions with which acute pancreatitis may be confused demand urgent surgery and it is better to err on the side of operating than to risk allowing a fatal condition to progress unchecked

The abdomen is opened through a paramedian incision and the lesser sac opened where the diagnosis is confirmed by the finding of areas of granular fat necrosis It is best to open the sac through the interval between the stomach and transverse colon, although some surgeons prefer to incise the lesser omentum or the transverse mesocolon A large drainage tube is placed down to the organ. If an abscess is present this must of course be opened and drained care being taken to pack off the rest of the abdominal contents

Should the gall bladder be diseased and the patient s condition satisfactory it should be removed or drained after the removal of any stones present. If gross peritonitis is present, a suprapubic drain should be inserted.

The non-operative treatment is that of peritonitis, with careful regulation of the fluid and electrolyte content of the body Prophylactic antibiotic treatment should be given

Chronic Pancreatitis. This is uncommon though not exceptional It may be associated with gall-stones and inflammation of the biliary passages and may follow duodenal ulceration or arise spontaneously The organ may be larger and harder than usual, or is shrunken and sclerosed. It may produce a swelling in the epigastrium which somewhat resembles a pancreatic carcinoma, with symptoms of a dyspeptic type. Fixed epigastric pain and tenderness is often present. Diabetes may arise in certain forms of chronic inflammation offensive diarrhoea with undigested fat in the stools and rapid wasting are also suggestive symptoms. Operative treatment may be of value since pancreatic or biliary calculi may be found obstructing the duct apart from this benefit has certainly been derived by cholecystenterostomy giving drainage of the biliary passages.

Pancreatic Calculi. Pancreatic lithiasis is a rare condition, for less than 200 cases have been reported in the literature and a correct diagnosis was made in only a small proportion

There are two different types of calculi (1) True stones, consisting of carbonate of lime and found in the ducts and (2) false stones, or calcification of the parenchyma resulting from pancreatitis. In the case of false stones, the ætiological agent is in most cases to be found in disease of the biliary tract True pancreatic stones are rounded and smooth and cause considerable dilatation of the pancreatic duct Stones may become impacted and give rise to acute abdominal pain which radiates round the flank into the small of the back. X ray examination may reveal a stone. Changes in the stools are also an aid to diagnosis The stools may be bulky frothy and rather foul excess of fat is not usually present Jaundice may or may not occur depending on the situation of the stone and the presence of pancreatitis or associated disease of the biliary tract. Diabetes is quite frequently associated with pancreatic lithiasis. Treatment consists of exploration and removal of the stone

Pancreatic Cysts. These are of rare occurrence and are often due to previous trauma with the formation of a pseudo-cyst not actually associated with the substance of the pancreas but situated in front of it, and containing altered blood confined within walls which are fibrous and devoid of any epithelial covering. Rarer forms may be due to defective development of the organ and are sometimes found in association with polycystic disease of the kidney True dermoid cysts have been reported Cystadenomata sometimes associated with islands of Langerhans (and giving rise to symptoms of hypoglycæmia), cystadenocarcinomata and teratomatous cysts, are also described It is probable that other cysts found in this region are the result of developmental abnormalities of enterogenous or congenital origin.

Simple complete obstruction to the duct has been shown experimentally not to produce a cyst.

Occasionally a hydatid infection will give rise to a cyst in the pancreas.

The fluid in pancreatic cysts is turbid and brownish from altered blood alkaline in nature and contains ferments which will peptonize albumen and break down fat and starch.

Cysts are usually seen in men of middle age and attention may be drawn to them by their being felt when bathing, or by the vague abdominal symptoms to which they may give rise Usually dyspepsia is complained of jaundice or constipation may be produced if the common bile duct or transverse colon is sufficiently compressed

On examination the patient is often emaciated as the functions of the pancreas may be interfered with and the absorption of fat and digestion of protein diminished The complexion is dirty and unhealthy-looking The cyst can be felt as a rounded tense fluctuating or elastic swelling, placed deeply in the abdomen, immovable, but sometimes transmitting the aortic pulsation The relations of a cyst to the stomach and transverse colon vary the cyst primarily forms behind the stomach, but when it attains any considerable size it projects anteriorly and then most commonly approaches the abdominal wall below the stomach and above the transverse colon (Fig. 47 18) More rarely it presents above the stomach (Fig. 47 19) or below the transverse colon (Fig. 47 20)

Treatment This is operative and consists in exposing the cyst either

in two forms, scirrhous and adenocarcinoma The former is the commoner and is usually situated in the head of the gland The patient complains of anorexia, loss of weight and dyspepsia, with epigastric pain as an early symptom in 50 per cent of the cases. The pain is of a boring character through to the back and restricting respiratory movements. It is unrelated to food position or movement and is often described as a pain from which



FIG. 47 21 A CASE OF CARCINOMA OF THE PANCREAS, SHOWING GREATLY DISTENDED DUODENUM.

there is no escape. Jaundice gradually supervenes and becomes absolute with an enlarged gall-bladder (see Courvoisier's Law). A barium meal may reveal a very dilated duodenum due to pressure of the growth on the third part of the duodenum and occasionally a tender mass may be palpable

Treatment The diagnosis of pancreatic carcinoma can only be confirmed by abdominal exploration If the growth is mobile if it does not

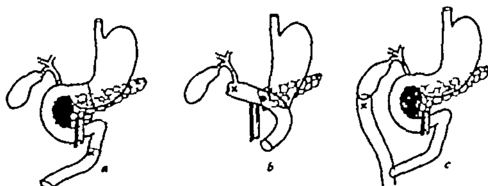


FIG. 47 22. CARCINOMA OF THE HEAD OF THE PANCREAS.

a. The stippled area shows the extent of resection of the stomach, duodenum, pancreas and common bile duct.
b The restoration after radical resection.
c. Palliative cholecystojejunostomy

involve any vital structure and if it has not metastasized resection should be attempted With the common type of growth in the head of the pancreas this operation entails removal of distal stomach and duodenum as well The common bile duct, stomach and pancreatic duct are anastomosed to proximal jejunum Very rarely however is the growth removable. In any case, the results are disappointing and it is better to be sure of giving the patient symptomatic relief by restoring the flow of bile into the intestine by doing a cholecystojejunostomy in Y operation, thereby short-circuiting the malignant obstruction Should a growth be found in the body or tail of the pancreas, however resection is well worth attempting.

Sarcoma of the Pancreas. *This is exceedingly rare and produces similar* signs to those of carcinoma

Biliary Strictures. Strictures of the hepatic and common bile ducts usually result from clumsy surgery When they are situated above the level of the duodenum and below the hilum of the liver they are best treated by careful dissection, minimal excision and end-to-end anastomosis over the upper end of a T tube the upright of the T being brought out through a separate incision in the common duct below the anastomosis This tube must be left *in situ* for some months until healing of the duct is complete During that time irrigations should be done regularly

When the stricture is below the duodenum a clean dissection is unlikely to be possible but the upper dilated common duct can usually easily be found. This is anastomosed end to end with a loop of jejunum (choledocho-jejunostomy in-Y) It is done over a T-tube the upright limb being brought out through a hole in the jejunum below the anastomosis.

When the stricture extends to the porta hepatis, the dilated proximal duct can only be found by cutting up into the liver along the natural lines of cleavage. An anastomosis of some form is constructed, the hepatico-jejunostomy in-Y The difficulties are formidable and the results disappointing.

THE SPLEEN

The spleen is situated in the left hypochondrium its long axis corre*sponding with the axis of the tenth rib Its upper border extends as high* as the upper border of the ninth rib and its lower border to the lower edge of the eleventh rib *It extends as far forward as the anterior axillary line* It is not normally palpable, except in young children.

Functions. The spleen is not essential to life and its removal leads to no lasting disability It acts as a reservoir of red blood cells and by active contraction it can deliver these cells to the circulation in times of emergency such as shock and hæmorrhage The spleen plays an important part in the metabolism of red cells. In the fœtus it plays a formative role, but in the child and adult its action is mainly destructive It also removes old or abnormal leucocytes and platelets In myelosclerosis, or other conditions of bone marrow atrophy the spleen may resume its formative role and islets of hæmopoietic tissue may be found in its substance.

The changes following removal of the spleen may thus be summarized.

Changes in the Blood (1) *Anæmia* The fall in the red cell count is associated with a fall in the hæmoglobin percentage and diminished fragility of the red cell. The anæmia usually recovers in two to six months.

(2) *Leucocytosis* At first this is a polymorphonuclear leucocytosis, but later this is replaced by a lymphocytosis which persists for some months.

(3) *The Platelet Count* Following splenectomy the platelet count at first rapidly rises, next falls below normal and then fluctuates for a long period

Changes in Other Organs The lymphatic nodes enlarge and there is proliferation of all the reticulo-endothelial system There is frequently an increase in red marrow Any splenunculi will hypertrophy this point being of some importance when splenectomy is advised for diseases of the spleen associated with blood destruction

While the above remarks apply to the normal spleen and changes which normally obtain after splenectomy these are capable of wide variation.

Abnormalities of Position. The spleen may vary greatly in its position



FIG. 47 23. DIFFUSE CALCIFICATION OF THE SPLEEN.

if its aberrations are severe the term *wandering spleen* is applied. *Accessory spleens* are present in 20–30 per cent. of persons. They may be one or two in number rarely more. A wandering spleen may be due to congenital defects or injury The spleen may also be displaced because of its gross enlargement A wandering spleen may be found in the thorax in a diaphragmatic hernia—in the left or right iliac fossa, or even in the pelvis In most of these cases the spleen has a long narrow pedicle and congestion and engorgement is inevitable. A more serious complication is torsion this leads to strangulation—a serious acute abdominal catastrophe The symptoms of wandering spleen in the uncomplicated state are those of vague abdominal discomfort and flatulent dyspepsia A floating or wandering spleen may have to be treated by splenectomy Occasionally calcification of the spleen may occur (Fig. 47 23)

Enlargement of the Spleen. Splenomegaly or enlargement of the spleen is found in most splenic affections The enlargement is in the long axis of the spleen *i.e.* it follows the line of the tenth left rib and an enormously enlarged spleen may finally arrive in the right iliac fossa The tumour moves on respiration and the hand cannot be introduced between it and the costal margin It is dull to percussion but a resonant note may be found behind it in the flank (*i.e.* the colonic resonance) The final and most characteristic feature is the fact that a deep notch or sometimes notches is found on the anterior or superior edge

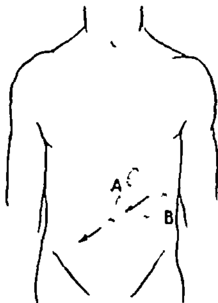


FIG. 47 4 DIAGRAM TO CONTRAST AN ENLARGED SPLEEN WITH AN ENLARGED LEFT KIDNEY
A, Notch on anterior border B, area of resonance behind tumour
Arrows show direction of enlargement.

The condition has to be differentiated from an enlarged left kidney a tumour of the stomach or of the splenic flexure of the colon a cyst of the pancreas or omentum, or great enlargement of the left lobe of the liver Careful examination will usually render a diagnosis easy

The Surgery of the Spleen. Surgically little can be done for splenic diseases other than the removal of the organ This is urgently necessary when the spleen is injured or ruptured Splenectomy is certainly indicated in acholuric jaundice thrombocytopenic purpura, primary splenic anaemia neoplasm, prolapse or torsion splenic arterial or arteriovenous aneurysm, and in some cases of congestive splenomegaly It may be of great value in chronic malaria schistosomiasis, kala azar hydatid disease, sarcoidosis, cystic disease of the spleen or solitary cyst and exceptionally for chronic splenic abscess or gumma. Blood diseases may benefit from splenectomy—such as the acquired hæmolytic anæmia of childhood and adults thalassæmia and sickle-celled anæmia Infective conditions may be associated with an enlarged spleen which may sometimes be removed with benefit, examples being Felty s syndrome, Still s disease and amyloid disease The rare metabolic disorder of porphyria congenita may also be improved by splenectomy The spleen becomes enlarged in leukæmia, Hodgkins disease,

lymphosarcoma, aplastic and myelosclerotic anæmia and, if its destructive activities govern the clinical picture splenectomy should be undertaken to give temporary benefit. Lastly the spleen should be removed to extend the resection and improve the approach in operation on œsophagus, stomach or pancreas. The spleen should *not* be removed in polycythæmia rubra vera in refractory anæmias due to excessive irradiation, luminous paint or benzol poisoning, and radioactive isotopes nor should splenectomy be done when it is judged that it has undergone myeloid metaplasia

Ruptured Spleen. Rupture of the spleen may be of traumatic origin or due to disease The former namely traumatic rupture is the commoner Spontaneous rupture of a normal spleen is exceedingly rare When spleno-



FIG. 47 25 LARGE CYST OF SPLEEN SEEN ON SECTION.

megaly due to malaria, typhoid, or blood dyscrasias is present spontaneous rupture, due to minor injuries, is not rare. Obviously this liability is much greater in the tropics.

Traumatic rupture of the spleen appears to be on the increase in this country and after a blow in the left chest or abdomen, or a run-over accident, its possibility should never be overlooked Two main clinical varieties occur

(1) *The Classical Type* Following the injury which usually is associated with much shock, the signs of intraperitoneal hæmorrhage develop immediately

(2) *The Delayed Type* Following the injury the patient suffers from a moderate degree of shock which typically responds to the usual measures. There is some pain in the left hypochondrium but this gradually passes off After an interval which varies from forty-eight hours to as much as three weeks, the signs of intraperitoneal hæmorrhage develop and the condition like type 1 becomes of grave urgency

It will be seen that while type (1) is the more immediately dangerous, type (2) is the more insidious In over 30 per cent of the type 2 cases the patient has been discharged back home or to work after the causative injury and before the onset of the hæmorrhage A careful watch should therefore be kept in such patients for left subcostal pain often with referred areas to the left shoulder in these cases. As ruptured spleen is common only in young healthy adults, such injuries must always be carefully treated in about 10 per cent other viscera are also damaged A typical case can be considered in three stages The stage of shock, the stage of recovery from shock but commencing hæmorrhage and the stage of advanced hæmorrhage

consequent hypersplenism is due to some other cause e g portal obstruction leading to the congestive splenomegaly of Banti's syndrome or reticulosis such as lymphosarcoma where the disease of the spleen is part of a systemic malignancy In this type of splenic anæmia splenectomy may be of benefit if blood destruction *per se* is an important factor in the clinical picture.

Essential Thrombocytopenic Purpura Hæmorrhagica. Purpura is a condition in which numberless hæmorrhages, some of petechial size and others larger occur in the mucous membranes and in the skin. It may be associated with many medical conditions, but that named above is of greatest surgical importance.

This is a condition occurring most commonly in older children, though no age is exempt Bleeding may also occur in the brain or in the spinal cord with the production of neurological signs and symptoms, or into the kidney with hæmaturia as the presenting complaint. There seems to be no familial tendency in the disease which, however is always accompanied by a profound drop in the platelet count which in normal blood numbers 250,000 to 400 000 per c.mm., but may in the severe cases of this disease be reduced to a thousand or so The deficiency is the cause of hæmorrhages and in these patients the bleeding time may be prolonged to fifteen minutes or more. The coagulation time however remains normal.

Acute and chronic forms of the disease are recognized. In the former the bleeding may be so severe that the blood loss may overwhelm the patient. In the chronic form small hæmorrhages are persistently occurring, although there are periods when the patient is apparently free from loss. However a blood-cell count will reveal a secondary anæmia and the petechial hæmorrhages may be induced to occur by a tourniquet fastened tightly round the patient s arm and allowed to remain for a few minutes (Hess s test).

The spleen is not palpably enlarged. This distinguishes primary thrombocytopenic purpura from that of secondary hypersplenism It must also be differentiated from anaphylactoid purpura (Schönlein s disease Henoch s purpura) and many other conditions causing petechial hæmorrhages such as scarlet fever septicæmia bacterial endocarditis scurvy drug eruptions, hypoprothrombinæmia, and even such states as fat embolism and traumatic cyanosis

In *Henoch s purpura* which affects younger adults and children, the typical lesion is a serohæmorrhagic effusion into the wall of the intestine, causing fever severe colic, vomiting, sometimes even of blood-stained material, constipation which is so resistant as to suggest obstruction and even intussusception. If there are no other purpuric manifestations the diagnosis is difficult. The absence of abdominal rigidity may help while the frequent history of rheumatism preceding the abdominal pain is noteworthy

In the *Schönlein* type there are effusions into the periarticular tissues

Treatment Purpura calls for surgical aid in certain of its manifestations All the primary purpuræ in their acute states are benefited by transfusion and many by cortisone Later the condition should be investigated to consider the value of splenectomy this is always indicated in cases of essential thrombocytopenic purpura hæmorrhagica.

Acholuric Jaundice. This disease is of considerable surgical interest. It is frequently congenital and familial in origin though spontaneous adult cases occur The disease consists of slight jaundice with absence of bile

from the urine which contains an excess of urobilinogen and a normal bile content in the fæces The essential factor is excessive fragility of the red blood cells. These are readily destroyed by the spleen which is usually enlarged This blood destruction in turn stimulates the bone marrow into a hyperactive state and the peripheral blood contains an increased number of reticulocytes, the excess over normal following closely the degree of blood destruction There may be few symptoms at first though the jaundice may be obvious. The serum bilirubin is elevated and tends to fluctuate giving a delayed reaction on the van den Bergh test unless there are stones in the

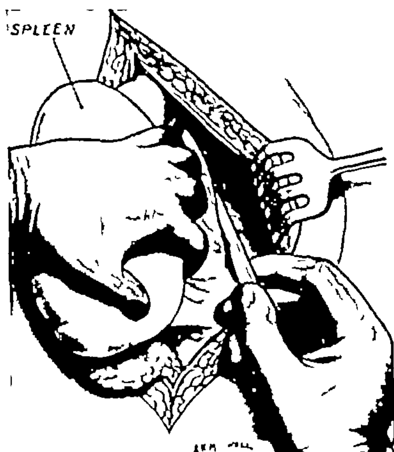


FIG. 47 26. SPLENECTOMY DIVISION OF THE PERITONEUM ON THE OUTER SIDE OF THE PEDICLE

common bile duct A special characteristic of this condition is the tendency to form pure pigmented gall-stones. These may be definite pigment stones, or the whole bile may be thick with pigment particles, the condition being termed "biliary mud" Acholuric jaundice is one of the rare conditions where stones can form primarily in the ducts rather than in the gall bladder That this can happen is a point of considerable practical importance when operative treatment for these stones is contemplated

During the course of the disease crises occur which are associated with excessive blood destruction Operation should not be done during such a crisis.

Treatment During a crisis the treatment is entirely medical. The curative treatment during an interval is splenectomy If this is undertaken early the results are extremely gratifying It is vital that all accessory splenic tissue should be removed Jaundice disappears promptly and there is great improvement in the anaemia and general well being. It should be done before stones have developed. At splenectomy the condition of the biliary passages should be investigated At the same time or at a later date, cholecystectomy cholecystotomy or choledochostomy may be required.

Splenectomy Three incisions are commonly employed in cases of

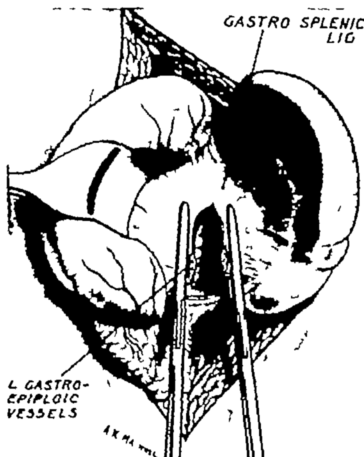


FIG. 47 27 SPLENECTOMY DIVISION OF THE GASTROSPLENIC LIGAMENT

trauma an exploratory paramedian incision extended to the costal margin in the form of a T if necessary for most cases of straightforward splenectomy a left subcostal incision and for cases of exceptional difficulty an oblique incision extending the line of the tenth rib to the umbilicus. Whatever the approach, the exposure must be good.

In removing small spleens it is usually better to start by dividing the gastrosplenic ligament between clamps and securing the splenic artery A large spleen should first be delivered and the left leaf of the lienorenal *ligament divided. This allows the spleen to be brought further up into the* wound so that the splenic pedicle may be approached from behind. The

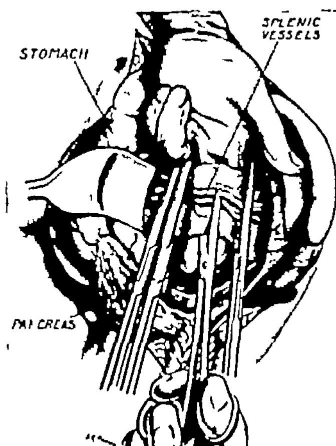


Fig. 47 28 Splenectomy Division of the First Pedicle containing the Splenic Vessels.

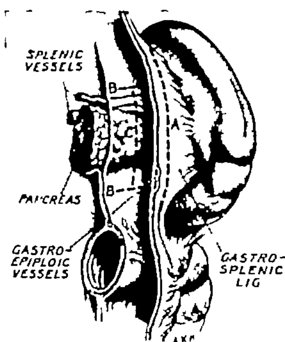


Fig 47 29 Splenectomy showing the two Pedicles which require to be Clamped and Divided.

main vessels are dissected, secured and divided, and the spleen is removed after its ligamentous attachments have been divided between clamps.

A very difficult adherent spleen is removed with least damage through the oblique incision, after division of the costal margin Sometimes it may be necessary to extend the incision up into the chest and divide the diaphragm, so that the spleen may be removed together with its adherent peritoneum, the so called extraperitoneal removal Blood loss may be heavy so enough cross-matched blood must be available Absolute hæmostasis must be secured *When many attachments have been divided the oozing areas* should be oversown with running catgut stitches after individual vessels have been tied off Such cases, and those in which the pancreas has been injured, must be drained.



FIG. 47 30 CONGENITAL PORTAL VEIN OBLITERATION.
Venogram by intrasplenic injection of 70 per cent. Diodone.

PORTAL HYPERTENSION

Portal hypertension is not a disease but a state in which the flow of portal blood is impeded. The obstruction is either *intrahepatic* in cases of cirrhosis hepatis (85 per cent) or *extrahepatic* (15 per cent) when either the portal or splenic veins are obliterated, compressed or thrombosed. Thrombosis of the portal vein is also present in about 12 per cent. of cirrhotics.

Pathology The commonest cause of extrahepatic obstruction is congenital obliteration of the portal vein A number of tortuous, thin walled, irregular venous channels replace the portal vein and envelop the common bile duct (Fig. 47 30) a condition known as a *cavernoma. It probably results* from an extension of the process that obliterates the umbilical vein and the ductus venosus at birth. More rarely the portal vein is constricted at the porta hepatis.

Acquired portal obstruction may be due to traumatic or infective thrombosis, or compression or invasion of the portal or splenic vein by a displaced organ or tumour Lastly splenic arteriovenous aneurysm will of course, lead to portal hypertension

The causes of portal obstruction outlined above may all be termed intrahepatic or prehepatic A more remote interference to the portal flow develops as a result of an obstruction to the hepatic veins (Budd-Chiari syndrome) or a deficiency of cardiac function such as constrictive pericarditis These may be referred to as post hepatic but are hardly within the province of the surgeon

The normal portal pressure is about 100 mm of water It varies considerably with the physiological activity of the alimentary canal and with the arterial and venous systemic pressures Anomalies are encountered from time to time especially in cases where there is an enlarged spleen possessed of a very copious blood supply This excess of blood flowing to the spleen may be reflected in an elevation of the pressure and an increase of the speed of flow of the blood leaving the spleen It may be termed physiological hypertension. A pathological state of portal hypertension on the other hand is always associated with stasis and congestion within the portal tree. The dammed up blood finds its way into the systemic circulation at every point of contact between portal and systemic venous systems. The collateral channels in the falciform ligament (with the umbilical and par umbilical veins) in the paracolic and parasplenic gutters (veins of Retzius) between splenic and renal veins and along omental adhesions, are all beneficial. Even at the rectum and anus the development of hæmorrhoids is rarely of clinical significance At the cardiac end of the stomach and up the œsophagus, however the varices which develop in the submucosa are dangerous They become very large and may carry off a considerable proportion of portal blood Placed immediately deep to the mucous membrane at a part of the body where erosions and ulceration commonly occur they are very liable to rupture and bleed copiously Surgical treatment aims at preventing a recurrence of such hæmorrhage.

The spleen is the only parenchymatous organ within the portal bed to be significantly affected by the venous congestion It sometimes becomes greatly enlarged and over-active, leading to a splenic anæmia of the secondary type The white cells and platelets are also materially reduced This may also be an indication for surgical treatment

Œsophageal varices and an enlarged spleen have come to be known as *Banti's syndrome* In its purest form this syndrome exists only when the liver is normal or the cirrhosis minimal. In the disease originally described by Banti the enlarged spleen, etc was associated with a deteriorating cirrhotic liver the development of ascites and ultimate death This variable association with cirrhosis makes the definition of Banti's syndrome difficult. The term portal hypertension has come into being and the numerous clinical manifestations of the diseases which give rise to it are accepted within the term. Thus in cases of cirrhosis hepatis, there may be obvious evidence of liver failure and little sign of œsophageal varices, or vice versa in cases of congenital portal vein obliteration the liver will be normal

Hæmorrhage Hæmorrhage from œsophageal varices is a complication which may be very dangerous in itself and which may lead to further acute deterioration of an already failing liver It is a matter which can be prevented

from recurring only by surgical means. The hæmorrhage itself should be treated by transfusion if that fails, by balloon tamponade and if bleeding continues, by œsophagotomy and ligature of the bleeding varices. Hæmorrhage is the prime indication for surgical treatment

Ascites Occasionally in cases of ascites patients do not respond to medical treatment, yet show clear signs of reasonable liver function. It is in these that the reduction of portal hypertension by surgical measures may cure the ascites.

Methods of Investigation. Cases of portal hypertension need, therefore,

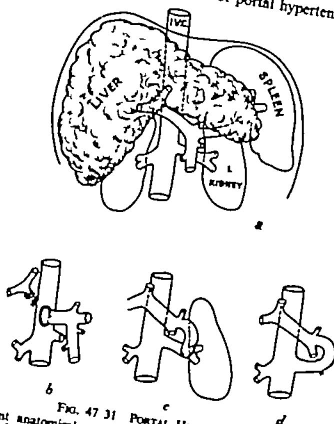


FIG. 47 31 PORTAL HYPERTENSION.
a. Significant anatomical relationships of portal and splenic veins.
b Portacaval anastomosis, end-to-side.
c Splenorenal anastomosis, end to-side.
d. Splenorenal anastomosis, end to-end.

to be assessed and investigated with the greatest care. The source of bleeding from œsophageal or even gastric varices must be demonstrated radiologically or by œsophagoscopy The full blood picture must be disclosed in order to assess the part played by the spleen. The function of the liver must also be fully investigated the most useful tests being an estimation of the serum proteins, the bromsulphthalein elimination test and an estimation of the blood prothrombin and its response to vitamin K therapy Flocculation and turbidity tests have been found to be of little help as a guide to treatment or prognosis. The function of the other vital organs needs to be assessed For example it is essential that an intravenous pyelogram should have been done before the patient reaches the operating table since it may be necessary to remove the left kidney if a splenorenal anastomosis is to be

done (Fig 47 31). This emphasis on the ancillary methods of investigation does not in any way reduce the necessity for a complete and careful clinical assessment of the patient

Medical Treatment In every case treatment is instituted on intensive medical lines An ascitic patient for example receives treatment for three months before operative intervention is contemplated whether there has been hæmorrhage or not The diet should be high in animal protein vitamins and carbohydrates It should contain the minimum of salt and no salt is added to the food during its preparation or serving at table Fluids are restricted to between 2 and 3 pints a day Supplementary vitamins may be given if necessary Mercurial diuretics may be helpful in assisting the body to dispel excess fluid and peripheral œdema In administering sedatives and analgesics only those drugs with no toxic effect on the liver should be allowed.

Surgical Treatment *Portal systemic Venous Anastomosis* It has been known since the days of the Russian physiologist Eck that the dog could survive the construction of an anastomosis between the portal vein and the inferior vena cava. This method of diverting portal blood directly into the systemic circulation is made use of in reducing portal pressure. In most cirrhotic patients direct anastomosis between the portal vein and the inferior vena cava gives the most satisfactory result (Fig. 47 31b) Should there be no portal vein, as in cases of extrahepatic portal obliteration the splenic vein may be used by anastomosing it to the renal vein (Fig. 47 31c and d) This operation is also indicated when removal of the spleen itself is necessary to eliminate the dangers of gross splenic anæmia, leucopenia or thrombocytopenia. A stoma of between 10 and 20 mm diameter can almost invariably be constructed and promptly relieves portal congestion. In the case of portacaval anastomosis, thrombosis of the stoma is exceptional with the splenorenal anastomosis on the other hand, the veins are less easy to handle, one of them may become kinked or otherwise obstructed, the stoma itself is smaller and thrombosis is, therefore more probable

The demonstration of veins suitable for anastomosis must constitute the most important part of the preliminary investigations of any operation involving the portal venous tree This is done by the injection of about 30 ml. of 70 per cent. diodone into the portal system, either by percutaneous injection into the pulp of the spleen or by direct injection at operation into a small radicle of the portal vein, usually a jejunal vein. The former method can be utilized before the operative incision is made the direct method can be used only after the abdomen has been opened. On some occasions it is advisable to use both methods.

The end results of portacaval or splenorenal anastomosis are very satisfactory provided the cases are carefully selected. The operative mortality is, however still appreciable (7 per cent.), but very small compared with the risks of repeated hæmatemesis.

About one in four of the cases recovering from operation sooner or later develop the peculiar condition of episodic stupor Evidence is accumulating to show that this is related to the " meat intoxication " in dogs when ammonia is excessive in quantity and cannot be metabolized rapidly enough. It produces toxic effects on the brain, however well the liver is functioning. Following portacaval anastomosis (or when there are copious natural portal-systemic venous anastomoses) blood from the alimentary canal is diverted

straight into the systemic circulation without giving the liver the opportunity of detoxicating the ammonia The symptoms are similar in many respects to those of hepatic coma due to liver failure The patients become disorientated and unable to work. The condition usually fluctuates and may be alleviated in the majority by restricting protein intake.

An altogether different approach to the surgical treatment of portal hypertension is a direct attack upon the bleeding segment of the alimentary canal. The œsophageal varices for example, may be injected with sclerosing solutions through an œsophagoscope. If they were the only dangerous structures, this would be an admirable method of treatment Unfortunately however the proximal end of the stomach also becomes varicose and may bleed profusely Similarly the operation of œsophagotomy and ligature of œsophageal varices may be effective in stopping œsophageal hæmorrhage but will not prevent it from recurring. In many parts of the world, therefore, the operation of proximal gastric resection has been developed in order to remove the bleeding segment and to isolate the œsophagus from all connection with the portal vein This operation can be of exceptional difficulty and danger and should not be undertaken except in those patients in whom the liver is normal or in whom the liver is functioning well

It must be stressed that this principle applies to all major operations for portal hypertension. No shunt or major resection should be done if the patient s serum albumen is below 3 2 g. per 100 ml

Chapter 48

THE COLON, RECTUM AND ANAL CANAL

Methods of Examination

The presence of symptoms referable to disease in any part of the intestinal tract calls for the examination of both abdomen and rectum It is foolhardy to treat abdominal symptoms without first examining the rectum and no less unwise to omit an abdominal examination when rectal symptoms are prominent After the abdomen the rectum is examined with the patient in the left lateral or right lateral position and particularly if sigmoidoscopy is to be performed possibly in the knee-elbow position

Digital Examination With a good light the condition of the anus and surrounding skin should first be carefully examined for skin changes tags the orifices of fistulæ etc. and the anal margins gently separated to determine the presence of a fissure The index finger well lubricated and pressed against the lateral wall is gently inserted The majority of rectal lesions occur within the last inch of the bowel After this has been carefully examined the finger is passed as far as possible and finally a bimanual examination is made

Proctoscopy and Sigmoidoscopy Both these examinations are of great value. The former permits the visual inspection of the rectal ampulla and as the instrument is slowly withdrawn of the anorectal junction This is perhaps the most common site for rectal disease It is the pile bearing area a common place for the internal openings of the fistulæ anal polypi and fissures. The sigmoidoscope gives a view of the interior of the bowel up to 25 cm but this is dependent on the variable anatomy and fixity of the rectosigmoid junction The instrument is a rigid tube and after its introduction it is passed under direct vision aided when necessary by distending the bowel with air The knee elbow position is convenient for these examinations for when the small intestine has fallen out of the pelvis, the walls of the rectum open up when air is introduced Note should be made of the mucosa, whether normal granular or ulcerated, the presence of blood or pus and a biopsy should be made of any suspicious area.

Barium Enema Apart from the rectum the confirmatory diagnosis of disease in the large bowel must be made on a barium enema It is dangerous to rely on the " follow through " of a barium meal to exclude colonic disease and even with a barium enema the rectosigmoid region is notoriously difficult to visualize

Examination of the Fæces This may be of importance in colonic disease. It may show evidence of parasites, red blood cells, pus cells or a positive occult blood reaction may be forthcoming.

Cytological Examination The examination of the cells obtained by bowel washouts has shown that on their appearance it is sometimes possible

to make a diagnosis of malignant disease. However this method requires careful training and great experience and is not yet in general use

Injuries and Wounds

Wounds of the colon are considered in Chapter 43

Injuries of the rectum may result from falls on sharp objects by the introduction of foreign bodies in play or perversity from pranks with air compressors from bomb-blast, and are not uncommon in warfare from wounds of the buttocks and abdomen when other viscera are frequently injured. The rectum may be injured in childbirth, by the injudicious use of a sigmoidoscope and even from a Higginson s syringe A most careful examination must be made the abdomen and bladder being always suspect. If hypogastric tenderness suggests an *intraperitoneal* injury laparotomy must be performed, the rectal wall sutured, the pelvis drained and a left iliac colostomy performed An associated bladder injury should be repaired and the bladder drained by indwelling urethral catheter *Extraperitoneal* injuries of the rectum should be carefully examined under an anæsthetic. The grave danger is of infection in the fat and cellular tissues around the rectum and to avoid this the wounds must be laid open to ensure good drainage due care being taken of the internal sphincter If the posterior wall of the rectum has been penetrated the presacral space may be drained by an incision beside the coccyx through the levator and the fascia of Waldeyer or by the removal of the coccyx. An injury to the bladder base or urethra should be repaired if possible Except in gross injuries, drainage by an indwelling urethral catheter is preferable to a suprapubic one After the removal of clothing, foreign bodies and necrotic tissue the wounds are sprayed with penicillin-sulphathiazole powder and are lightly packed Any serious rectal injury is best treated by a temporary left iliac colostomy

Post-operatively a suitable antibiotic and one of the sulphonamides should be given as a routine Gas gangrene is not uncommon after rectal injuries and a full prophylactic dose of the antitoxin should not be omitted Sulphaphthalidine emulsion may be injected into the distal colostomy opening. When sepsis is over secondary reparative operations may be necessary and not until sound healing is present should the colostomy be closed.

Foreign Bodies. These are derived from various sources Often they have been swallowed, and have traversed the intestinal canal Fish bones and small tooth-plates are most commonly seen they usually lodge just above the anus in one of the so-called " pouches of Morgagni " They give rise to severe pain especially on defæcation and possibly to some form of perirectal abscess. Large gall-stones are sometimes lodged in the lower end of the rectum just above the sphincter Foreign bodies may also be introduced from without, and cause various forms of traumatic inflammatory lesions

Inflammatory Diseases of the Colon and Rectum

Ulcerative Colitis. The ætiology of this condition is obscure but it is regarded as a psychosomatic disease and it is thought that the increase in the mucolytic enzyme of the colon, which is said to be present, is the result of emotional stimuli. Whatever the cause the changes in the mucosa range from a slight granularity to wide-spread ulceration. As the condition becomes chronic, fibrosis develops in the bowel wall, normal haustration

is lost narrowed areas appear in the colon and a barium enema shows a "gas pipe" appearance with a woolly outline through barium flecks in the uneven wall The disease is most marked in the rectum and sigmoid but the whole area of the colon is usually involved and in a few cases changes are also present in the terminal ileum Characterized by diarrhœa and the passage of blood and pus it may occur at any age but is perhaps most marked in young adults. While there are all gradations it is possible to recognize three clinical types the mild chronic, the severe chronic and the acute toxic. The first requires medical treatment and continued supervision, the second produces chronic invalidism and the third kills the patient unless arrested by surgery It is said that perhaps a quarter of all cases of ulcerative colitis eventually require surgery and the knowledge that longstanding cases of the disease show a definite tendency to develop carcinoma often multifocal in origin infiltrative in type and with a poor prognosis now leads to surgical treatment at an earlier stage

Indications for Surgery Surgery is occasionally called for in the acute stage when conservative measures appear unable to save the patient's life It is certainly indicated when there are permanent and severe organic changes in the bowel wall such as pseudo-polypi or stricture, when arthritis or skin ulceration show evidence of toxic absorption and when chronic invalidism makes it impossible for the patient to earn his livelihood.

The following operative procedures may be undertaken

(1) *Ileostomy* The ileum is divided at or near its junction with the cæcum the distal end closed and the proximal end brought out either through the wound or through a stab incision in the right iliac fossa The establishment of an ileostomy by preventing the passage of fæces over the ulcerated bowel usually produces a great benefit to the patient's health and the use of the modern adhesive bags has done much to lessen the disability Nevertheless, the diseased large bowel remains It has to be accepted that it can never be of use to the patient again and since its retention means continued sepsis, however mild, and the risks of carcinoma it should be excised

(2) *Total Colectomy and Ileostomy with Excision of the Rectum.* There is a tendency at the present time to perform total colectomy and ileostomy at the same operation The majority of patients can be made fit enough for the procedure and the disturbance of biochemical balance that may follow an ileostomy tends to be offset by the benefits derived from the removal of a septic organ. It is wise to remove the rectum as soon as the patient has fully recovered from the colectomy

(3) *Ileorectal Anastomosis* The rectum is always involved in ulcerative colitis but in a few cases its involvement is slight. It is occasionally possible to preserve the use of the rectum and after excision of the colon, to anastomose the terminal ileum to it. If this is done it must be realized that ulcerative colitis will remain in the rectum that it may worsen, that fistula, stricture or carcinoma may develop and that the frequent small intestinal evacuations may give the patient an intolerable pruritus. Nevertheless, the operation is sometimes justified and if it fails a return can always be made to an ileostomy

Medical Treatment Apart from some fanciful drugs and diets that have had their trial in the treatment of this disease, all varieties of the sulphonamides and antibiotics are used. Cortisone and ACTH are also widely used and in many cases effect improvement but not a cure, and some consider that their best use is as a preparation for surgery

Diverticulitis. Under the title diverticulitis is described an inflammatory condition arising in connection with the secondary *acquired multiple* false diverticula of the large bowel, most marked in the sigmoid colon. They are situated usually in rows, often projecting into the appendices epiploicæ. At first they are merely semi-globular pouches, consisting of all the intestinal coats, but later the muscle fibres atrophy and the pouches become more flask-shaped with a definite neck, but rarely are larger than a hazel nut.



FIG. 48 1 DIVERTICULA OF THE COLON.

Fæcal material enters and may become inspissated, so as to constitute an *enterolith foreign bodies may find lodgment* and thus the basis of a whole series of pathological phenomena very similar to those of appendicitis is laid. Acute inflammation occurs leading to ulceration, gangrene or perforation, followed by acute local or general peritonitis abscesses may develop opening externally or into some viscus *e g the bladder and leading* to fæcal fistulæ. In other cases chronic inflammatory hyperplasia results.

giving rise to the formation of a mass resembling a carcinomatous tumour and ending in stenosis Carcinoma itself is an infrequent sequel

Symptoms *Acute* diverticulitis usually occurs in those who have passed middle life and is twice as common in men as women The patients are often fat and well nourished and there is a history of preceding constipation The symptoms closely resemble those of appendicitis and indeed the term "left-sided appendicitis" has been applied to it The sigmoid flexure is usually involved and then the site of maximum tenderness may correspond to McBurney's point on the left side The symptoms of abscess formation and peritonitis have no peculiar features In the more *chronic* cases, the development of a tumour like chronic inflammatory mass is the most marked feature lying over the left side of the pelvic brim It is very likely to be mistaken for a cancerous growth and it is probable that most reported cases of the disappearance of a supposed intestinal cancer after operation of an exploratory type, are of this nature The points of differential diagnosis are that in diverticulitis the patient is generally in good health and somewhat obese. The history is of some duration and points to recurring slight inflammatory attacks in the left lower quadrant of the abdomen, usually with absence of blood in the stools. Radiography is of assistance in that the characteristic features of cancer are absent and it is often possible to demonstrate the presence of diverticula On rare occasions, the presenting sign of diverticulitis is severe hæmorrhage from the large bowel.

Treatment In the *pre-inflammatory* stage (the so-called "diverticulosis"), treatment is only called for when there are symptoms. It consists of simple enemata to clear the lower bowel the administration of small daily doses of liquid paraffin and the avoidance of all roughage (*e g.*, pips, skin and fibre) in the diet In the *acute* stage treatment is akin to that for acute appendicitis abscesses are opened and drained and the communication with the colon will then often close itself by granulation. Excision of the affected portion of the colon is desirable some six months after the initial operation. For the chronic hyperplastic type excision is the only effective treatment, followed by end-to-end or lateral anastomosis in a few cases a permanent colostomy has to be established. The existence of fistulous communications with the bladder is no contra indication to operation if the sigmoid is set free, it is not a difficult task to close the vesical opening and the result is likely to be satisfactory

Proctitis. Inflammation of the rectum causes pain of a bearing-down character a sensation of fullness, constantly recurring tenesmus accompanied by a discharge of mucus, mucopus, or blood It may arise from any local source of irritation, *e.g* the presence of foreign bodies, or of a polypus, parasites, or piles gonorrhœa is an occasional cause—in women possibly owing to infection from the vaginal discharge, in men probably from direct infection. In the past much proctitis arose from the failure to wash thoroughly or change gloves when passing from one patient to another It seems that the rectum is well able to deal with its own organisms, but not with those transferred to it on a dirty glove In dysentery and in ulcerative colitis the rectum is often involved as well as the colon It may be tuberculous, follow irradiation of the cervix, occur with lymphogranuloma inguinale and occasionally is an allergic disturbance. In very many cases the cause is unknown. If the inflammation becomes chronic, a simple fibrous stricture may result In acute proctitis the mucosa is œdematous, inflamed, and

covered with mucopus in chronic forms it is thickened, granular and bleeds easily when touched with a probe Ulcers are not commonly seen.

Threadworms (*Oxyuris vermicularis*) are the most constant source of irritation of the rectum in infants and children. They give rise to pruritus ani, a discharge of mucopus, and many reflex phenomena In cases resistant to treatment the appendix may be the main site of the worms.

Bilharzia hæmatobia may infect the rectum where it gives rise to papillomata within which the ova may be demonstrated. Infection of the bladder which is much more common, usually coexists. This condition is found in some portions of Egypt, where it is very common, and in other tropical regions. The living ova can be destroyed by intravenous injections of antimony but the papillomata persist and need to be dealt with by operation.

Treatment Any exciting local lesion should first be excluded and a smear of the pus examined. In acute cases the patient is confined to bed, and if necessary a starch and opium enema, or mildly astringent suppository given to relieve pain and tenesmus, while liquid paraffin will prevent the formation of hard fæcal masses. Apart from the treatment of any specific cause the therapy of this condition ranges from the systemic administration of penicillin and the sulphonamides and the local application of the latter in suppositories and wash-outs to painting the rectal mucosa with silver salts. Recoveries and intermissions may be unrelated to the treatment, which is frequently disappointing. Secondary anæmia must be treated.

Syphilitic Disease of the Rectum and Anus. The rectum and anus are attacked by syphilitic disease in a variety of ways, the more common being as follows

(1) The initial lesion of primary chancre is occasionally met with in the neighbourhood of the anus.

(2) In the secondary stage mucous tubercles or condylomata are frequently seen, being placed either at the anal margin, or symmetrically on either side of the gluteal fold the sores on one side having evidently infected the other They are of the usual type, and are treated locally by dusting with powdered calomel and keeping a piece of dressing between the lips of the fold.

(3) Tertiary syphilitic lesions of the rectum and anus are occasionally found but at the present time are undoubtedly very rare Cases regarded in the past as gummatous infiltration of rectal mucosa sometimes with associated disease of the vagina and external genitalia, were almost certainly due to lymphogranuloma venereum

Treatment The usual treatment for syphilis should be adopted.

Tuberculous Disease of the Anorectal Region. Chronic abscesses and fistulæ in this region may be tuberculous, from the bowel in those with active pulmonary disease from the blood stream and by extension from tuberculous disease of other structures such as the spine pelvis or prostate. It is therefore important that a histological examination should be made of the granulation tissue in any suspicious case If superficial they should be treated in the usual manner with diathermy to the raw area. If deep they are frequently inoperable In all cases the patient s general condition will require treatment and a full course of streptomycin PAS and isoniazid will eventually lead to healing in the most extensive cases.

Fibrous Stricture of the Rectum. This occurs mostly in women over forty years of age and is usually situated 4 to 10 cm from the anus or as high

as its junction with the sigmoid flexure. In this position it is generally due to the cicatrization and contraction of ulcers following prolonged diarrhœa and dysentery although occasionally it follows tuberculous or syphilitic disease. Any form of chronic proctitis *e.g* *gonorrhœa* may also lead to it. It occurs sometimes as a sequel of pelvic cellulitis and suppuration, from the contraction of fibrous bands which may bind the rectum backwards to the sacral wall or may merely constrict it Repeated attacks of inflamed piles may also lead to stenosis at or just above the anus. A stricture some times results from traumatism or follows operations involving the whole or at any rate the greater portion, of the circumference of the bowel. It may in addition be associated with a fistula, especially if the latter has existed for long, and is then due to a chronic inflammatory fibrosis lighted up by the persistent irritation of the bowel the inner opening is then found in the substance of the stricture The use of radium in the treatment of anal and cervical carcinoma occasionally produces an anal or rectal stricture *Lymphogranuloma venereum* a venereal disease due to a filter-passing virus with a predilection for the lymphatic system may in women produce a rectal stricture by the fibrosis which follows the involvement of the pelvic lymph spaces around the rectum Pressure of the fœtal head in prolonged labour is another possible cause Lastly a congenital stricture may result from the persistence of part of the proctodeal membrane

Symptoms The difficulty in passing motions becomes more and more marked until no relief is obtained apart from medicine This is associated with pain and uneasiness referred to the lower bowel a certain amount of blood and mucus may be mixed with the excreta and sooner or later marked dyspepsia and abdominal distension supervene In untreated cases obstruction may result and lead to a fatal issue or the mucous membrane of the bowel above the stricture becomes ulcerated an abscess forms, and subsequently a fistula, through which a certain small amount of fæcal material passes. Digital examination will reveal the presence of the stricture

Treatment In the early stages this consists in keeping the bowels regular and the motions soft by means of paraffin and laxatives, or by enemata The diet is regulated, so that there is no unnecessary débris. Locally the stricture, if within reach should be dilated by means of bougies passed in increasing sizes every two or three days the utmost gentleness must be used in order to stretch the mucous membrane and not tear it. When situated low down the stricture may be notched posteriorly or slightly nicked in several places with a blunt-ended bistoury and bougies then passed. As these strictures always tend to contract again treatment is usually prolonged.

Colostomy will be required if ulceration and fistulæ are present or if the stricture is high and dilatation involves much risk

Perirectal Suppuration

Rectal and perirectal suppuration is not uncommon and is very liable to lead to the formation of fistulæ. It may be due to the impaction of foreign bodies the extension of ulcerative processes or the suppuration of piles. Occasionally the trouble starts in the skin around the anus and sometimes the pus reaches the perirectal tissues from other viscera *e g* the neck of the bladder prostate, etc or from above, in connection with spinal or pelvic abscesses. Occasionally the abscess is attributed to injury

or cold as from sitting on a damp stone or in a draught, but probably these are merely the final exciting agents.

Perianal Abscess. This forms immediately under the anal skin and superficial to the external sphincter (Fig 48 2) It may be due to infection of a perianal hæmatoma, spread from a fissure or infection of a sebaceous follicle It may be acute or chronic and is one of the most frequent causes of fistula-in-ano It must be freely opened throughout its whole length and packed. The packing is removed in this and all fistulæ at the end of about forty-eight hours, after which the wound is allowed to granulate from the bottom, a process which is encouraged by the patient sitting in a warm bath each day followed by light packing of the cavity

Submucous Abscess. This usually results from a suppurating internal pile (Fig. 48 2) The pus spreads up and down under the mucous membrane and gives rise to a blind internal fistula (Fig. 48 4) It is generally confined to one side of the bowel and causes great pain on defæcation. Digital examination is extremely painful. Treatment consists in draining it at the most dependent spot, close to the anus, but it is often necessary to slit up the undermined mucous membrane. If however the abscess extends high into the rectum, division of the mucosa may give rise to serious hæmorrhage In order to prevent this a probe director is insinuated into the lower opening and is pushed through the mucosa at its upper extremity Two silk ligatures are then tied to the end of the probe which is manipulated so that its end protrudes through the anus. The ligatures are then drawn down through the fistulous track and separated from the probe One is tied to include the mucosa to the right of the track the other to include the mucosa to the left. The intervening area sloughs and the abscess heals by granulating from the bottom

Acute Ischiorectal Abscess. This is due to infection of the loose fatty tissue filling the ischiorectal fossa (Fig. 48 2) the organisms reaching it either through the perineum or from the bowel The *Esch coli* is usually present and in consequence the pus has the characteristic offensive odour A red painful swelling is noticed on one side of the anus which is at first hard and brawny but soon becomes soft and fluctuating Defæcation is exceedingly painful, as also digital exploration of the bowel and the patient is unable to sit with any comfort. If left to itself it may burst internally or externally or in both directions, and a fistula in-ano is very liable to follow An abscess in one ischiorectal fossa may spread across behind the anus to involve the other side and the fistulous opening which is often present in these cases is usually found in the midline posteriorly between the internal and external sphincters

Treatment Any abscess in this region should be opened at once since any delay increases the risk of a fistula. Under efficient anæsthesia a cruciate or T-shaped incision is made and the flaps cut away to allow adequate drainage (Fig. 48 3) If the abscess has extended to the other ischiorectal fossa both sides and the communicating track should be laid open and lateral relieving incisions made If a subsphincteric fistula is present it may be laid open by passing a probe through the internal orifice between the two sphincters into the bowel and dividing the external sphincter or marked with a silk thread and divided at a subsequent operation

At the end of the operation the wound should be lightly packed with a suitable dressing and subsequent to its removal irrigations and baths should

e g a psoas abscess from spinal disease, appendix abscesses, etc. Rectal examination indicates the existence of a painful swelling high up in the bowel. As soon as a diagnosis is made the abscess should be freely laid open on to the surface in the ischiorectal region and to facilitate drainage a small incision may be made into the levator ani in the direction of its fibres. The abscess must never be laid open into the bowel or incontinence will result. Usually the abscess will heal only at the top, leaving a residual track to the surface This again must be laid open fully at a second operation, a third or fourth being sometimes required before healing is complete Of course an abscess which is secondary to a tuberculous spine is an exception to this rule

In serious infections of the ischiorectal fossæ a gas infection may be present with surgical emphysema, due to the *Cl perfringens* the *Esch coli* or to streptococci. Extensive incisions may be necessary and healing may be slow The antibiotics are of great assistance in these cases, though they do not in any way replace the need for prompt and proper surgery

Fistula-in-Ano

The term fistula-in-ano is somewhat loosely applied to all conditions in which suppurating tracks are found in the neighbourhood of the anus and the lower end of the rectum. Some of these are merely sinuses which

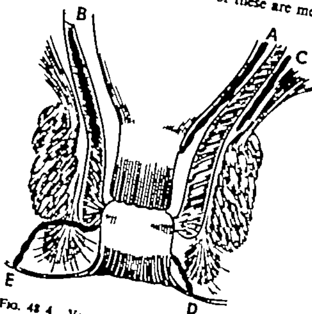


FIG. 48 4. VARIOUS FORMS OF FISTULA-IN-ANO.
A, submucous B intermuscular C, anorectal D subcutaneous E, subsphincteric or anal.

have but one opening. Fistulæ are usually due to rectal or perirectal suppuration They are classified on the relationship of the track to the ano-rectal musculature.

Subcutaneous Fistula. The track lies in the perianal region. Three varieties of them are recognized (Fig. 48 4) (*a*) the blind external, in which the orifice is external to the anus (*b*) the blind internal in which the orifice is just inside the anal canal and nearly always associated with a

fissure (c) the complete fistula in which are present both internal and external orifices

Treatment This is simple A probe pointed director is passed along the track of the fistula and the overlying tissues are divided longitudinally A few lateral relieving incisions are made and the ulcer allowed to granulate from the bottom

Subsphincteric or Anal Fistula *The track is deep to at least part of the* external sphincter The internal orifice may be low entering the anal canal between the lower border of the internal sphincter and the subcutaneous external sphincter or high, when it enters immediately below the anorectal ring. Both these fistulæ may be associated with submucous extensions The internal orifice of high anal fistulæ is usually found in the midline posterior and " horse-shoe " extensions to either side may occur

Treatment *In all cases the track must be laid open and relieving* incisions made. This will necessitate division of the external sphincter muscle, but this is of no consequence In those cases in which the external orifice is situated on or in front of a transverse line dividing the anus the internal orifice between the two sphincters is situated radially opposite Where, however the external orifice is behind this line the track takes a curved course backwards to open in the midline posteriorly In high anal fistulæ the division of the external sphincter may be carried out in two stages, the track being marked by a silk thread and the final division of the sphincter left to the second operation.

Submucous Fistula. There are four varieties of this (Fig. 48 4) (a) blind external, in which the pus under the mucosa has gravitated downwards to open at the anal margin (b) blind internal, in which the opening of the fistula is inside the lumen of the bowel, usually associated with a tear of the mucosa, or a torn anal valve or polyp (c) complete, in which both internal and external orifices are present (d) bilateral in which the abscess is situated above the internal sphincter and before opening in the midline posterior spreads laterally to form a T-shaped fistula.

Treatment This has been indicated in discussing submucous abscess.

Intramuscular Fistula. This is a rare form, lying between the two muscular coats of the rectum It is rarely more than 2 cm. long (Fig. 48 5).

Treatment This consists in laying open the fistula into the bowel.

Anorectal Fistula. This, the worst type of fistulæ may occur as a result of perforation of the rectal wall above the internal sphincter There are three varieties of this fistula (a) blind internal, which is really an abscess cavity situated between the fascia propria and the longitudinal muscle and communicating through a small opening with the lumen of the bowel (b) complete, in which the abscess present in the first variety has broken through the levator ani muscle to involve the ischiorectal fossa and eventually to perforate through the skin (c) bilateral, in which the original abscess has tracked round the rectum before bursting through the levatores ani on either side.

In either of these two latter varieties there may be many subcutaneous extensions in the ischiorectal fossa and in addition there is often present a subsphincteric fistula.

The diagnosis of this type of fistula depends on the fact that the original abscess is *recognized on rectal examination* above the internal sphincter and if the condition is complete a grooved probe director when passed

from the external to the internal orifice will not be felt clearly on rectal examination on account of the thickness of muscular tissue which lies between it and the examining finger

Treatment On no account must this type of fistula be opened into the bowel, as by so doing the internal sphincter will be divided and permanent incontinence will result

In the blind internal type a knife must be plunged into the ischiorectal fossa and guided by a finger placed in the rectum through the levator ani



FIG. 48 5 BILATERAL ANORECTAL INTRAMUSCULAR FISTULA AFTER THE INJECTION OF LIPIODOL INTO THE FISTULOUS TRACT

into the abscess cavity large radiating incisions are made into the tissue and skin of the ischiorectal fossa to ensure as adequate drainage as is possible. By the time these incisions have almost healed the abscess cavity at the tip of the pyramid thus formed will have closed considerably from the apex, leaving a small fistulous track to the skin A second third, or even fourth operation is then required, following the lines indicated with laying open of the fistulous track freely on to the surface Following each operation the abscess closes from the top healing at the level of the skin taking place

In the complete variety the same procedure is followed, except that in this case the original incisions radiate from the fistulous track. In addition the opening of the fistula through the levator ani may be slightly enlarged by a small incision in the direction of its fibres

In the bilateral type the operation described must be carried out in both ischiorectal fossæ. Any subsphincteric or subcutaneous extensions must of course be dealt with

After Treatment It is necessary to keep the bowels confined for three or four days after the operation to procure this it is essential to empty the bowel completely before operation. The patient is therefore given a purge on the evening before admission and on the following morning magnesium sulphate mixture (Mist. Alb). During the day a very light diet is allowed, and in the evening an enema is given. No further treatment is usually required on the morning of operation but where the bowel has been excessively loaded a wash-out may be given.

The first dressing is removed in forty-eight hours and the wound may then be syringed frequently with hydrogen peroxide or hypochlorite very light packing only being subsequently introduced into its cavity During

In the third or fourth stage of piles however where protrusion is occurring either with defæcation only or with any act of straining whatsoever the constant trauma gives rise to ulceration in spite of the thickened epithelium, so that once more bleeding occurs

Symptoms The symptoms are often not very marked until hæmorrhage occurs but there is usually a sense of weight or fullness about the anus, with sometimes pain, which is increased before and after defæcation. The patient feels as if a foreign body were present, the mass not unfrequently

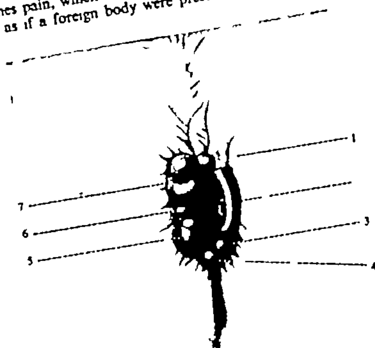


FIG. 48 6. INTERNAL PILES.

1 left anterior secondary
2, left lateral primary
3, left posterior secondary
4 posterior secondary
5 right posterior primary
6, right lateral secondary
7 right anterior primary

protrudes, giving rise to pain and inconvenience, owing to the grip of the sphincter they can however be easily replaced by the patient. Sooner or later hæmorrhage is almost certain to occur coming on at first after defæcation and only a few drops being lost. After a time, however the flow increases and may continue to such an extent as to cause marked anæmia. If the case remains untreated, the pain and inconvenience increase a blood stained mucous discharge from the rectum is noticed reflex irritation of neighbouring organs is produced and considerable distress from pain and hæmorrhage may result. Where the piles are due to portal obstruction as in cirrhosis of the liver the bleeding may be beneficial and need not always be checked. There is often an associated perianal irritation due to the skin being continually moistened by the rectal discharge

Complications Thrombosis of a hæmorrhoid may occur This often becomes infected and may go on to develop into an abscess subsequently discharging into the lumen of the bowel In other cases the abscess may burrow deeply to produce a fistula on rare occasions suppurative pylephlebitis or pyæmia may be added to complications Where severe infection is not present a thrombosed pile subsequently becomes organized into fibrous tissue and may give rise to one form of fibrous polyp of the rectum *Strangulation* of the piles by the sphincter ani may follow protrusion where

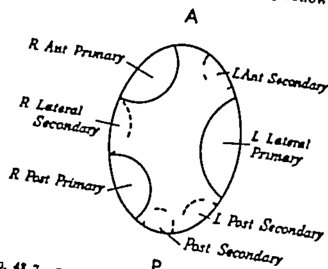


FIG. 48 7 SITUATION OF PRIMARY AND SECONDARY PILES.

reposition is not effected the mass becoming painful tense, swollen and livi in colour inflammation progressing to ulceration and sloughing follows and a spontaneous cure may be effected.

The treatment of internal piles is both general and local.

General Treatment This consists in removing all possible sources of venous congestion, in regulating the bowels and assisting the functions of the liver When dependent on the pressure of a gravid uterus, as little as possible should be done beyond attending to the regular action of the bowels until the child is born, because with the relief of the pressure subsequent to delivery the condition improves greatly of its own accord

Local Treatment This may be by injection or operation.

(1) *Injection* This is suitable for small and uncomplicated piles without much prolapse A proctoscope is introduced and 3 to 5 ml of a 5 per cent. phenol in oil solution is injected into the submucous space at the base of each pile. The injection should produce a pale swelling over which the minute blood vessels are visible. It is usual to inject up to a total of 10 ml. and repeat this when necessary in a few weeks time.

(2) *Operation* That in most common use is ligature and excision. A purge is given thirty-six hours before and an enema the evening before operation. Under anæsthesia the anus is dilated and the rectum swabbed. The three primary pile masses are then picked up with artery forceps If there is a prominent skin fold in association with a primary pile this is also picked up and with scissors a triangular incision is made its apex towards the anus, its base including the skin fold. If no skin is to be removed the

incision is made at the mucocutaneous junction The dissection passes inwards towards the anus, displaying the termination of the longitudinal muscle of the bowel The pedicle of the pile is now transfixed and ligated with stout catgut or silk. Following the three primary piles, any prominent secondary pile may be picked up and tied. The pile masses are now cut away their pedicles replaced, the ligatures cut long, a lubricated drainage tube introduced into the rectum and small pieces of Vaseline Gauze tucked in beside the tube Some surgeons omit the tube.

Careful after treatment is required. Morphine should be given to relieve pain and the bowels confined for three days After the first motion the patient is allowed to go to the bath. A finger should be passed into the rectum as soon as the ligatures have sloughed off The raw areas of mucosa tend to unite longitudinally instead of transversely producing a stricture, and this is prevented by digitally smoothing the mucosa every day for about three weeks The patient is retained in hospital for about twelve days, during the latter part of which time he is instructed how to do the finger exercise

Post-operative retention of urine is a common inconvenience after operations in this region intramuscular injection of carbachol will often relieve it.

Perianal Hæmatoma. Running around the anus under the skin of the anal margin is a plexus of veins. One of these veins is very easily ruptured in acts of straining, whether it be at stool or in heavy muscular exercise. There is then *formed under the skin a bluish swelling consisting of blood clot which* is extremely painful When small, complete absorption will take place but if the clot is large or the overlying skin is breaking down operative removal is indicated. Under a little local analgesia, the skin over the clot should be cut away and the congealed blood evacuated These perianal hæmatomas are sometimes referred to as external piles.

Redundant Skin Tags. Around the anus is sometimes a redundancy of skin tags which are often associated with pruritus ani These tags cannot always be snipped away as part of the treatment of the irritation, and if associated with piles they are removed at the time of operation

Anal Fissure. A crack in the anal margin is caused by overstretching during defæcation It may be associated with an anal polyp or arise in an anal canal habitually used to a fluid stool when more solid fæces are passed. It is most common in the midline posterior where the decussating superficial fibres of the external sphincter give least support and the subcutaneous sphincter fibres cross the gap The condition tends to become chronic through attachment, spasm and fibrosis of the underlying muscle and is characterized by an œdematous skin tag at its lower end (the " sentinel pile ").

The symptoms of this condition are very distressing consisting of burning pain during and after defæcation The pain which often lasts for hours, is usually associated with tenesmus and may radiate down the thighs, up the back, or to the left sacro-iliac joint it may be so severe as to lead the patient to refrain from defæcation for prolonged periods The fæces may be streaked with blood or pus. On examining the part, the sphincter is found to be contracted spasmodically and the entrance of a finger is forcibly resisted

Treatment In the earlier stages this consists in regulating the action of the bowels by suitable laxatives, by the use of analgesic suppositories

or to defæcation and by improving the general health Sometimes : application of a silver nitrate stick combined with the subchloride of rcury ointment is most effective in giving relief Five ml of an oil uble local anæsthetic solution such as Proctocaine may be injected into : tissues around and behind the sphincter The anæsthesia produced and : relief of spasm may be sufficient in an early case to start healing Local plications of ichthyol are very soothing.

Operation should be performed if the fissure is chronic, with indurated ges, if there is a small polyp at the upper end and a large tag at the base if internal piles or a fistula are present Operation consists in the division the contracted muscle, the excision of the anal tag and any associated al polyp The regular use of an anal dilator until sound healing has taken ice is an essential part of the after-treatment

Pruritus Ani. This condition is characterized by intense and incessant hing of the anus and its surrounding skin At first noticed mainly at night d interfering with sleep it may in time persist both day and night, erfering with the patient s work and wearing him out through want of ep Scratching becomes a necessity yet aggravates the condition It ay be due to threadworms, excessive sweating a fungus infection a fistula lergy or neurosis. In many cases the causation is obscure and scratching eps up the condition of the skin

Treatment This must first be directed to any local cause Careful giene, the use of a simple lotion such as equal parts of lotion of lead subetate and lotion of calamine at frequent intervals, a sedative and the strict oidance of scratching will often effect a cure. Cortisone ointment is metimes most effective. In severe cases the injection of Proctocaine ound the anus may break the scratch habit and allow the skin to recover om the constant trauma In obstinate cases Ball's operation *is sometimes* ed. This consists in dividing the sensory nerve supply to the anus and rianal region by undercutting the skin on either side of the anus

Proctalgia Fugax. This is a rare condition in which the patient, more ten female than male and usually *in* mid-adult life, develops attacks of vere cramp-like pain in the rectum sometimes lasting a few minutes metimes a few hours. The attacks may awaken the patient from sleep e pain is believed to be due to muscular spasm and in some cases produced by rectal distension Anxiety is believed to play a part and it is a *character* istic of the condition that no organic cause can be demonstrated. Apart from sedation, the actual attacks have been helped by such diverse forms of treatment as taking a hot bath, inhaling amyl nitrite or going for a walk.

Rectal Prolapse

A certain tendency to eversion of the mucous membrane of the bowel is a constant accompaniment of the act of defæcation sometimes, how ever this persists after the evacuation of the bowels is concluded, constituting a condition of prolapse. At first only the mucous membrane is protruded, constituting an *incomplete* prolapse if however the whole thickness of the bowel, mucous membrane, submucosa and *even the* muscular and serous coats is involved it gives rise to the *complete* variety (Fig. 48 8) The former condition (sometimes badly termed a prolapsus ani) is more commonly met with in adults and the latter (the so-called prolapsus recti) in children but it must be understood that the latter is always pre

ceded by an incomplete stage, limited to the mucous membrane and that in adults complete prolapse is occasionally observed.

Causes (*a*) Laxity of the sphincter may occur in weakly individuals and especially when chronic constipation or diarrhœa has caused the evacuation of the bowels to be accompanied by straining. In children malnutrition following measles and whooping cough may predispose, while the loss of fat from the perirectal cellular tissue may assist (*b*) Conditions which have led to chronic tenesmus or violent expulsive efforts *e g* piles, chronic constipation, diarrhœa, rectal irritation as from polypus or worms in children, or diseases of neighbouring organs, such as vesical calculus, stricture or enlarged prostate, may also determine prolapse

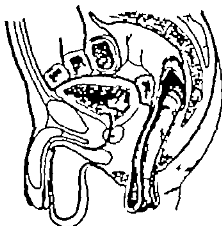


FIG. 48 8. LONGITUDINAL SECTION OF COMPLETE PROLAPSUS RECTI

Symptoms and Diagnosis The anal orifice is occupied by a smooth rounded swelling, red or purplish in colour covered by mucous membrane this protrusion in the early stages can be easily replaced, but returns when the patient coughs or strains. When the swelling is of large size, reduction is increasingly difficult and painful, from infiltration and fibrous overgrowth of the submucosa. The exposed mucous membrane is very liable to become inflamed and ulcerated Prolapse of the mucosa alone seldom exceeds a length of 5 cm. and may occur on one side only If both sides are involved,

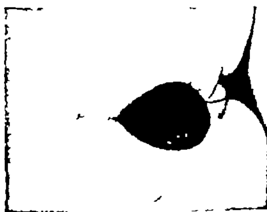


FIG. 48 9 PROLAPSE OF THE RECTUM. The patient is lying on her side.

there is an indentation anteriorly and posteriorly not present in complete prolapse or procidentia recti When the whole thickness of the gut is protruded the serous lining may accompany the tumour but this is usually limited to the anterior surface Into the sac thus formed small intestine or omentum may pass and even become strangulated The prolapse itself may also be constricted if allowed to remain for long unreduced the mass is then livid, swollen and intensely painful. If left to itself it may slough and thus lead to a spontaneous cure, although severe septic symptoms may supervene and even perforation and peritonitis.

There should be little difficulty in recognizing a prolapse the only condition for which it can be mistaken is an intussusception protruding from the anus in this, however the finger or a probe can be inserted into the rectum by the side of the protruding gut, which is impossible with a prolapse.

Treatment In the earlier stages, all that is needed is the removal if possible, of the cause of the tenesmus, *e g* dilatation of a urethral stricture removal of a vesical calculus, or the regulation of the bowels so as to check either chronic diarrhœa or constipation. When piles are present, they should be treated as described above and the prolapse will, as a rule, subsequently disappear Threadworms must be dealt with by suitable means (*q v*) It is advisable for the individual to acquire the habit of having the daily motion at bedtime, while children should have the buttocks supported when they defæcate. The prolapse is carefully washed, reduced by pressure with the fingers and retained by strapping the nates together or by applying some suitable pad and a T bandage. Faradism to tone up the sphincter and levatores ani may be of assistance, and in children palliative treatment of this type is usually successful, or spontaneous cure occurs.

In some cases light cauterization of the mucous membrane has been advocated. This produces adhesions between the mucous membrane and the muscle coats.

In adults, however operative treatment has frequently to be undertaken. In those cases where there is a prolapse of the mucosa alone ligaturing of the latter in three segments namely right anterior right posterior and left lateral, as in the operation for piles, is often successful. Subsequent to the operation the patient must be instructed to develop the external sphincter muscle by periodically tightening it at intervals during the day

Complete rectal prolapse usually occurs in women If their general condition is good it is best dealt with by an abdominal operation which allows the removal of the deep peritoneal pouch of Douglas found in these cases and the fixation of the rectum by floss silk sutures or by anterior resection. If the patient is not sufficiently fit for an abdominal operation then rectosigmoidectomy should be performed. This consists in amputating the prolapsed bowel in the perineum and uniting the layers by suturing. It has a low mortality but recurrence of the prolapse is common after it and incontinence may follow or if already present, may not improve In still less suitable cases, or in cases of partial prolapse with a lax sphincter Thiersch s *operation* encircling the anal canal with a silver wire in the peri anal space, may be very helpful

After all these operations the patient should be instructed in anal exercises and given faradic stimulation.

In children with persistent rectal prolapse, Thiersch s operation may

be performed with fine chromic catgut alternatively a silk ligature may be introduced to encircle the anal canal the ligature being removed one or two months later

Innocent Neoplasms of the Colon and Rectum

Those of connective tissue origin are not common in the large bowel. Lipoma, fibroma and leiomyoma may occur and may become pedunculated and give rise to an intussusception Angiomata may be of the multiple variety and cause severe bleeding. Argentaffin or "carcinoid" tumours also occur and may metastasize The common innocent tumours are of epithelial origin and are adenoma and papilloma. They are more common in the rectum and sigmoid but may be found anywhere and it is thought that at least 20 per cent. of bowel carcinomas have started in these tumours.

Adenoma. This is a compact mass of proliferating glandular tissue, in its early stages resembling a split pea as it lies in the mucous membrane At first sessile, it tends to become pedunculated. This tumour is not uncommon in childhood when it may bleed or prolapse but then shows no tendency to become malignant.

Papilloma. This is a soft velvety tumour whose unit of construction is a frond like process with a central core of blood vessels and a covering of mucus-secreting cells Sometimes called a villous papilloma it may cover a wide area and both by sight and touch it may be difficult to determine its exact edge It is most common in the rectum

Histologically many innocent tumours show a mixed structure, an appearance similar to that found in many carcinomas. It is not uncommon to find early malignant change in their structure, they are often found in proximity to a carcinoma and in the case of villous tumours of the rectum those kept under observation for prolonged periods have usually ended in carcinoma.

Symptoms They are either discovered through bleeding, by routine sigmoidoscopy rarely through obstructive symptoms and in the case of the rectum occasionally through their prolapse or the passage of mucus.

Diagnosis In the rectum the tumour may be felt or seen with the sigmoidoscope or proctoscope Elsewhere the diagnosis will be made by a barium enema or perhaps detected at laparotomy

Treatment If the tumour is pedunculated and in the rectum it may be possible to prolapse it under an anæsthetic and transfix the stalk If within reach of the sigmoidoscope it may be removed by diathermy snare or destroyed. At higher levels laparotomy will be required and either opening the colon and removing the tumour if it is pedunculated or resecting an area of the bowel wall if it is sessile At such an operation the interior of the adjacent bowel should be examined since other tumours may be present Whenever possible, they should be submitted to histological examination Extensive villous tumours of the rectum present a difficult problem A negative biopsy does not give any evidence of what may be happening in the depth of the tumour If sufficiently high they may be treated by anterior resection otherwise there is a choice between repeated diathermy destruction which is unlikely to be wholly effective or a combined excision of the rectum

Congenital Familial Polyposis. In this rare hereditary disease the result of a gene mutation members of a family develop about puberty or early adult life areas of epithelial hyperplasia throughout the large bowel in the

form of adenomatous tumours with a tendency to become malignant. Both sexes are equally affected, either may transmit the disease and as a rule only half the children are likely to inherit Only those who inherit will transmit The severity and the likelihood of carcinoma supervening is worse when the disease begins early and when cancer does start it is often multifocal

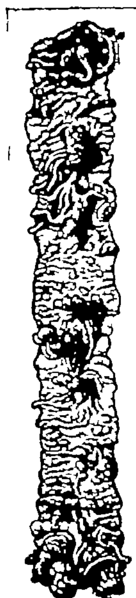


FIG. 48 10. SPECIMEN SHOWING MULTIPLE POLYPI OF THE COLON.

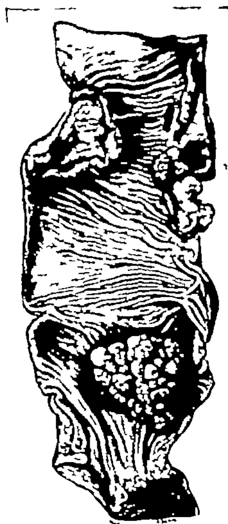


FIG. 48 11 CARCINOMA OF THE RECTOSIGMOID JUNCTION WITH A VILLOUS PAPILLOMA OF THE RECTUM.

in origin In mild cases sigmoidoscopic diathermy and regular supervision with barium enemata is required in the severe, or where carcinoma is suspect, total colectomy and ileorectal anastomosis is the ideal The rectal stump can be kept under post-operative supervision but if it is affected by carcinoma or its retention appears dangerous total colectomy and combined excision of the rectum with an ileostomy will be necessary

Malignant Neoplasms of the Colon and Rectum

Apart from carcinoma, other malignant tumours are rare in the large bowel but lymphosarcoma reticulum-cell sarcoma, spindle-celled sarcoma, *melanoma endothelioma, chordoma and malignant* carcinoid " tumours all occur The signs which they produce are usually indistinguishable from carcinoma and the diagnosis is made by biopsy or after excision of the tumour Recent work has suggested that when malignant carcinoid tumours metastasize to the liver there may be an increased secretion of serotonin an indole derivative secreted by the cells from which carcinoid tumours arise The patients suffer from diarrhœa borborygmi a tendency to telangiectasis, pulmonary stenosis and bronchial asthma.

Carcinoma of the Colon and Rectum. Carcinoma of the large bowel accounts for some 16 000 deaths in England and Wales every year and rivals



FIG. 48 12. CARCINOMA OF THE CÆCUM. (*King s College Hospital Museum.*)

carcinoma of the stomach in frequency Carcinoma of the colon is slightly more common in women, carcinoma of the rectum in men Its frequency throughout the world varies considerably It is rare in Iceland, common in Denmark uncommon in the Far East and South America and probably slightly more common in this country than in the United States. It may start in an innocent tumour develop in multiple polyposis or follow ulcerative colitis. Histologically the growth is an adenocarcinoma, apart from those in the anus, but there are all gradations between the highly differentiated and the anaplastic. Broders s grading of these tumours is of value in prognosis.

Pathology Carcinoma of the colon and rectum exists in three main forms the scirrhous type the hypertrophic type and the ulcerative type.

The *scirrhous* type is the commonest, especially in the left side of the colon the bowel being invaded by a sclerosing growth which, by its con-

traction, gradually produces obstruction to the passage of the fæcal contents of the intestine The growth is greater around than in the length of the bowel that proximal to it undergoing steady dilatation and hypertrophy in an endeavour to overcome the obstruction In the later stages the dilatation is much in advance of the hypertrophy the walls of the bowel being thinned and perhaps ulcerated this being particularly so in the case of the cæcum which may be so dilated as to fill the whole of the lower abdomen Perforation of the bowel may obviously result if the obstruction continues to its logical conclusion The bowel distal to the site of obstruction is sometimes dilated possibly due to the cutting off of its nerve supply by the growth. Ballooning of the rectum is an important diagnostic point of the presence of a growth beyond the reach of the finger

The *hypertrophic* type occurs most frequently in the cæcum (Fig. 48 12) or rectal ampulla and is rare in the pelvic colon It is of a low degree of malignancy but because it is later in producing signs and symptoms which bring it to notice, these patients are usually seen late It gives rise to a cauliflower like mass growing from the wall of the bowel which becomes ulcerated and bleeds, and eventually produces obstruction Colloid changes may be present.

The rarest type is the *ulcerative* type which rapidly metastasizes and erodes its way through the wall of the bowel This term is somewhat misleading since most growths show some ulceration.

Cancer of the Colon

The spread of the growth and the infection accompanying the ulceration may cause it to bind down the adjacent structures although the adhesions

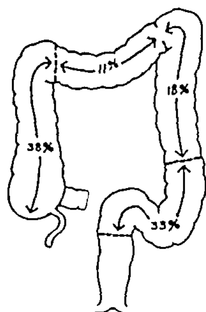


FIG. 48 13 DIAGRAM SHOWING THE RELATIVE FREQUENCY OF CANCER OF THE COLON.

are not necessarily malignant. Thus a carcinoma of the pelvic colon may become adherent to the bladder and in rare cases, perforate into this organ (the vast majority of vesicocolic fistulæ are secondary to diverticulitis), or it may stick and adhere to the Fallopian tubes or ovaries. Other cases may

steadily ulcerate through the colonic wall giving rise to a localized abscess or general peritonitis A fistula may be found between the stomach and transverse colon in cancer of the latter

Glandular spread occurs first in the paracolic nodes, then in those at the root of the mesentery Secondary metastases reach the liver through the portal vein *Direct extension of the growth will involve the peritoneum* and perhaps the ureters, so that the patient may die of urinary obstruction and infection. In late cases, where obstruction does not result, a generalized blood-stream extension may occur with secondaries in the brain, lung, bones, skin and other organs.

The part of the large intestine most commonly involved in carcinoma is the sigmoid the cæcum being the next in order of frequency Fig. 48 13 gives the site of the growth in a series of cases.

Carcinoma of the Right Colon. The onset of the condition is usually insidious, and the duration of the symptoms prior to diagnosis is usually



FIG 48 14. CARCINOMA OF THE CÆCUM
Note the irregular filling defect.

about six months Pain, usually colicky often brought on by food and in the mid abdomen or as a dull ache in the right side is the most common first symptom Loss of weight, occasional vomiting, diarrhœa or constipation are also common Anæmia with its associated symptoms of faintness or lassitude is present in nearly 20 per cent. of growths of the right colon In nearly two-thirds of the cases a mass is palpable on admission to hospital and in 10 per cent. acute obstruction is present A barium enema usually confirms the diagnosis The occult blood test is frequently positive Common errors are due to confuse the symptoms with those of gastric origin or appendicitis.

Cases of carcinoma of the right colon are therefore, commonly seen

before any obstruction has occurred and the patient can be well prepared for the operation which consists in excision of the cæcum ascending colon hepatic flexure and part of the transverse colon as well as the terminal 15 cm of the ileum (Fig 48 15) As for all cases in which a severe abdominal procedure is contemplated the patient should be admitted to hospital some five days prior to the time of operation in order that he may be rendered as fit as possible for his ordeal A blood count is carried out and if any anæmia is discovered a transfusion should be given Breathing exercises are taught to the patient so that following the operation he may be better

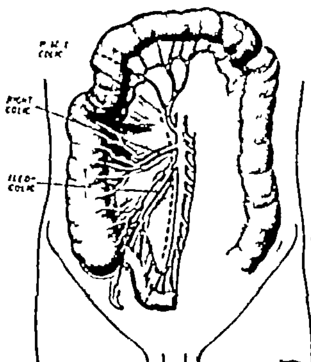


FIG. 48 15 THE EXTENT OF RESECTION OF THE GUT REQUIRED IN CARCINOMA OF THE CÆCUM.

fitted to breathe properly and avoid chest complications A general medical examination will be carried out and the blood urea determined

Four days before operation a course of phthalylsulphathiazole and two days before an oral antibiotic are given These drugs sterilize the bowel contents, so that contamination of the peritoneum during the actual resection is reduced to a minimum

During this time too great attention should be paid to the patient s diet and his fluid intake should be at least 4 pints daily

The Operation The best incision is a right paramedian packs being inserted to keep the small intestine out of the field, only the bowel to be removed to be kept in view The peritoneum along the outer side of the ascending colon and cæcum is incised and the bowel stripped up from the posterior abdominal wall together with its blood and lymph supply (Fig. 48 16) Care is taken to avoid injury to the ureter and spermatic vessels. The hepatic flexure is freed by blunt dissection and snips with scissors, but care must be taken not to damage the retroperitoneal portion of the duodenum. Clamps are applied to the ileum which is then divided, the free end being oversewn

and invaginated The transverse colon is similarly treated after the corresponding portion of the omentum has been ligated and cut ready for removal The divided ends are united by end-to-end or side-to-side anastomosis The suture line is reinforced with the omentum The final stage is to reperitonize the raw area left by the incision made on the outer aspect of the colon and the section through its vessels The abdomen is closed with drainage which should never be omitted because of the exudate from the raw area on the posterior abdominal wall. The tube may be brought out through a separate stab wound.

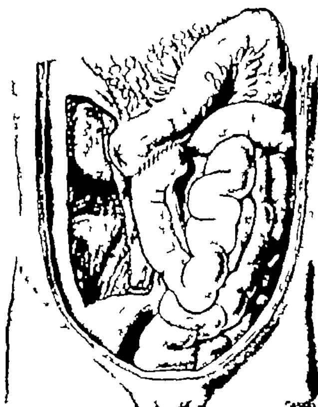


FIG. 48 16 THE COMPLETED OPERATION FOR EXCISION OF THE CAECUM FOR CARCINOMA. If a raw surface is left on the posterior abdominal wall because of lack of peritoneum, it may be covered by omentum so as to prevent the formation of adhesions.

Carcinoma of the Transverse, Left and Sigmoid Colon. Although obstruction, with some alteration in the bowel action may occur in all cases, it is clear that these signs will manifest themselves earlier in cases of carcinoma of the pelvic colon than in carcinoma say of the hepatic flexure because the stools are much more solid lower down and more readily held up. Moreover bleeding and the discharge of mucus, which may be quite slight but definite is more mixed with fæcal material in high growths and may go unnoticed by the patient In carcinoma low down the bright blood and the mucus rarely fail to escape his attention

Signs and Symptoms Patients come complaining of a variety of symptoms. It may be constipation or diarrhœa or the two alternating with one another colicky pain due to increased peristalsis, pain across the back (where the growth has extended to involve nerves), or they may have noticed

increasing abdominal distension Others complain of the passage of blood and mucus, or frequency and burning on passing water while some have noticed loss of energy and weight with the increasing paleness of anæmia

Occasionally these patients are seen when obstruction is acute and then a history of absolute constipation for several days will be given but careful enquiry will reveal some of the symptoms mentioned above of months duration Acute obstruction is more common with carcinoma of the sigmoid than in any other site



FIG. 48 17 BARIUM ENEMA SHOWING CARCINOMA OF THE TRANSVERSE COLON AND DIVERTICULOSIS IN THE SAME PATIENT

On examination, the patient may show obvious signs of loss of weight and in some cases of cachexia. The abdomen may be distended, mostly along the lines of the large intestine and it may be possible to percuss or palpate a grossly distended cæcum The actual tumour is often not palpable, although impacted fæces, recognizable by their indentation when subjected to pressure, may be identified The liver should be examined for enlargement and in some cases secondary deposits with typical umbilication can be palpated. A rectal examination with the patient lying on his right side,

enables a tumour to be palpated through the rectal wall higher up than if the subject lies on his left side because the colon tends to fall on the examining finger

Even when sigmoidoscopy reveals a growth a barium enema should always be given as occasionally a second may exist at a higher level

Treatment This is surgical except in those few cases where obstruction is not imminent but the presence of ascites, an enlarged liver with palpable secondary deposit and general cachexia show that death is near These



FIG. 48 18 CARCINOMA OF THE RECTOSIGMOID JUNCTION.
Oblique view showing carcinomatous stricture. It is important to take an oblique view as an ordinary antero-posterior view may not reveal the stricture.

patients are best treated conservatively The operative procedure consists in the removal of the affected gut, together with its lymphatic drainage and as this will often entail the removal of the blood-supply of a large area of bowel this latter must also be removed. In cancer of the transverse colon this and the two flexures should if possible be excised in disease of the splenic flexure, the distal half of the transverse colon and the descending colon will require removal For the sigmoid colon, a more limited resection consisting of about 10 cm of gut above and below the cancer together with a wedge-shaped excision of the corresponding part of the mesentery may suffice, but many prefer to treat these sigmoid growths as for a recto-sigmoid carcinoma and ligate the inferior mesenteric artery below the left colic branch

There are, however dangers attached to these apparently technically easy operations which in the past have accounted for many deaths, but which can nowadays be prevented by efficient pre-operative treatment and

the performance of a two-stage operation if necessary These patients are often in poor condition and all should be admitted some five days before operation in order that they may be given a nourishing low residue diet containing plenty of fluids. If their blood-count and hæmoglobin warrant it a blood transfusion is invaluable In addition a course of Sulfathalidine and an oral antibiotic is given as has been indicated previously

In operating on these patients there are two factors that go against success. Firstly the bowel contents are still infectious and if allowed to

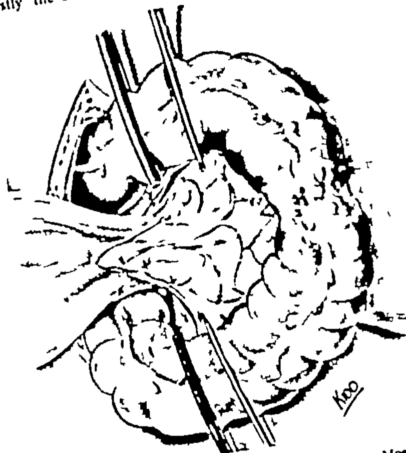


FIG. 48 19 SHOWING HOW THE CLAMPS ARE APPLIED AFTER MOBILIZING A GROWTH IN THE SIGMOID COLON

come into contact with the general peritoneal cavity will give rise to general peritonitis secondly the bowel above the obstruction is dilated and perhaps œdematous, considerably larger in diameter compared with the bowel below to which it is anastomosed which makes it very dubious as to whether a water tight union can be effected, especially as one side of the bowel may not be covered with peritoneum The bowel can in many cases be cleansed and the œdema reduced to such an extent that a safe one-stage operation can be performed by the following treatment. On the morning of admission the patient is given ½ oz. (14 ml) magnesium sulphate mixture followed by ¼ oz. (7 ml.) every hour for four hours. On each succeeding day until forty eight hours before the operation that is for about ten days, he is given a further ¼ oz. (7 ml.) of the mixture. Each morning during this period the

patient is given a colonic wash-out. If at any time during this period of preliminary treatment, signs of obstruction supervene, a cæcostomy must be performed Under this treatment the patient will visibly improve, losing his toxic appearance, while the distension of his abdomen disappears

The abdomen is explored *via* a paramedian incision and the operability of the growth estimated Peritoneal involvement, the presence of masses of nodes, secondaries in the liver will all indicate that only a palliative procedure can be attempted This may take the form of a short-circuiting

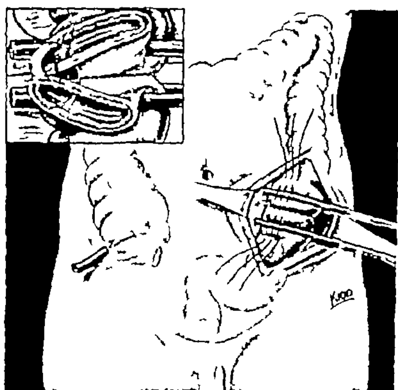


FIG. 48 20 SHOWING THE COMPLETION OF THE OPERATION FOR RESECTION OF THE SIGMOID COLON WITH END-TO-END UNION.

A cæcostomy has been performed some days previously The inset demonstrates the method of suture.

operation whereby the bowel proximal to the carcinoma is anastomosed to that distal to it by a side to-side anastomosis, or a colostomy performed in the transverse colon if the site of the obstruction is distal to this Where the condition is operable a resection along the lines indicated is performed, the descending and pelvic colon being mobilized by incising the peritoneum along their outer margin Where the ileum is anastomosed to the transverse colon, a side-to-side or end-to-end anastomosis may be used but elsewhere end-to-end re-establishment of continuity is desirable

In anastomosis on the left side of the abdomen it is a good plan to extraperitonealize the line of suture, by stripping up the parietal peritoneum on the lateral abdominal wall and suturing it to the peritoneum on the inner side of the bowel above and below the junction A drainage tube is then brought out through a stab-wound made in the flank so that if

leakage does occur it is extraperitoneal and not associated with general peritonitis.

A further measure of safety is to bring a small piece of the cæcum out on to the surface and fix it there by sutures so that if any abdominal distension occurs, relief of tension on the suture line may be effected by opening the viscus and converting it into a cæcostomy.

In all cases where the preliminary treatment has failed to diminish the sure and œdema of the distended bowel all procedures should be preceded by preliminary colostomy or cæcostomy.

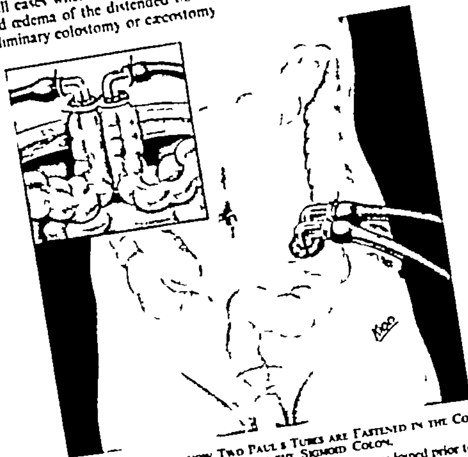


Fig. 48 21 Showing how Two Paul's Tubes are Fastened in the Colon after Resection of the Sigmoid Colon.
The smaller drawing illustrates how the two loops of the colon are joined prior to inserting the Paul's tubes.

An alternative method, which has much to commend it, is the operation associated with the name of Paul and Mikulicz. The bowel above and below the tumour is mobilized by incising the peritoneum along its outer border. It is stripped inwards carrying with it the blood and lymphatic supply. When sufficient mobilization has been carried out the two limbs of the gut above and below the tumour are sutured together for fully 8 cm. two rows of seromuscular sutures being employed. The whole loop of gut is then brought outside the abdomen either through a separate incision in the iliac fossa or through the main incision, the abdomen being closed. The peritoneum is sutured snugly to the two united loops at the top of the union (Fig. 48 21).

The diseased gut is then removed and a Paul's tube tied into each of the open ends. At the end of a week or ten days when the tubes have loosened

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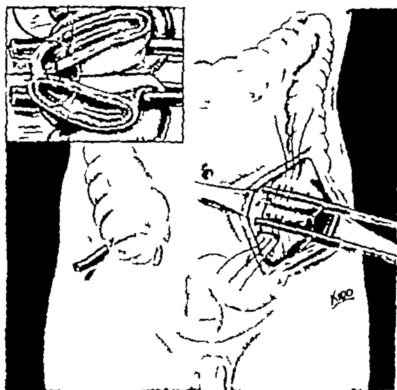


FIG. 48 20. SHOWING THE COMPLETION OF THE OPERATION FOR RESECTION OF THE SIGMOID COLON WITH END-TO-END UNION.

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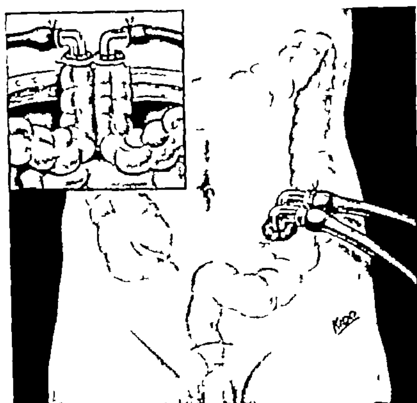


FIG. 48 21 SHOWING HOW TWO PAUL'S TUBES ARE FASTENED IN THE COLON AFTER RESECTION OF THE SIGMOID COLON.

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The diseased gut is then removed and a Paul's tube tied into each of the open ends. At the end of a week or ten days when the tubes have loosened

they are removed and the common wall between the two limbs of gut is crushed by means of a crushing clamp or enterotome so that it sloughs away Direct continuity between the gut is thus re-established and the opening on the abdominal wall becomes increasingly smaller A small subsequent operation will close it entirely

There is, perhaps, one criticism of the Paul-Mikulicz operation, and that is that it does not always allow the excision of a generous margin of normal intestine or of the segment of the mesentery that contains lymph nodes

Where acute obstruction exists, a cæcostomy in desperate cases is all that the patient will stand, exploration being postponed until he has recovered. In other cases a laparotomy should be performed because an idea can then be obtained as to the operability or no of the tumour and appropriate treatment carried out.

When perforation has taken place the patients are often *in extremis* The surgeon can only do a colostomy or cæcostomy in the region of the perforation and drain the abdomen Subsequently resection may be possible

Results While operability rates vary it is probable that some 70 per cent. of all cases of carcinoma of the colon are operable and that some 30 per cent. of all admissions to hospitals are alive five years after the resection

Cancer of the Rectum

Carcinoma of the rectum is one of the more common forms of cancer and while it usually occurs in the "cancer age," it occasionally affects young adults.

It may start in three situations (*a*) In the upper part of the rectum near the rectosigmoid junction. Thus, the most common site is at the tip of the examining finger and a growth here may easily be missed if a somewhat cursory examination is made of the anus and rectal ampulla (*b*) In the rectal ampulla (*c*) Just within the anus. This is an uncommon situation.

Pathology The growth is a columnar-celled adenocarcinoma and is usually found as an ulcer with raised hard everted edges It is occasionally a large projecting tumour colloid degeneration is not uncommon and it may be the termination of multiple adenomatosis. Apart from the latter condition small adenomata are frequent in the proximity of a carcinoma and it is probable that many rectal cancers start as an adenoma It is not uncommon to find more than one primary growth in the rectum or sigmoid colon.

The growth spreads by direct invasion, by the lymphatics and by the blood-stream

(1) At first confined to the mucosa the [illegible] the underlying muscle and graduall[illegible] of the bowel There is no definit[illegible]s more of [illegible]h in the rectum the amount of cir[illegible] between the [illegible] which it has pene trated the wall [illegible] volved and [illegible] 48 22) Stenosis and obstruction [illegible] which is so [illegible] the rectum and this may be [illegible] in the [illegible] case progresses it inv[illegible] ion [illegible] ome [illegible] parts [illegible]

adherent either to the pelvic walls or to the bladder vagina or prostate sometimes the iliac vessels or sciatic nerves are compressed causing œdema or neuralgia

(2) The lymphatics are seldom involved until the muscle coat of the bowel has been penetrated First the small lymph nodes lying in close proximity to the growth are involved then those along the superior hæmorrhoidal artery and finally the lumbar nodes. Lymph node enlargement does not necessarily indicate invasion but may be inflammatory The main lymphatic drainage of the rectum is in an upward direction but when the nodes above are blocked by growth, lateral or downward spread may take place and lateral spread also takes place with growths below the level of the peritoneal reflection

(3) Secondary deposits, carried by the portal blood-stream to the liver and by the systemic to the lungs and other organs also take place

Cuthbert Dukes has classified the pathological types of carcinoma of the rectum He has shown that the natural evolution of the disease is in its earliest stages limited to the mucous membrane and submucosa. (*a*) As

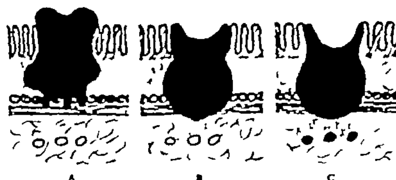


FIG. 48 22. DIAGRAM TO SHOW INVASION OF CARCINOMA OF THE RECTUM. (*After Cuthbert Dukes*)

it progresses, ulceration takes place on the surface and there is invasion of the muscle coats. (*b*) In both these stages local excision of the rectum may eradicate the disease When however the lymph nodes are affected (*c*) there is less chance of curing the disease by surgical procedures

Symptoms. These are often so slight and the onset so insidious as to raise no suspicions of the existence of any growth until it has attained considerable size The patient is usually an adult and more often male than female. The most common first symptoms are the passage of blood and some alteration of the bowel habit unusual constipation or diarrhœa The passage of blood and mucus apart from defæcation a sensation of incomplete bowel emptying and the onset of pain follow Lower abdominal discomfort is suggestive of a stenosing rectosigmoid growth. Digital examination may reveal a raised nodule an ulcer with an overhanging edge or a soft fleshy tumour Growths in the upper third of the rectum tend to prolapse and may resemble the cervix uteri. A careful assessment of the extent and fixity of the growth should be followed by a routine proctoscopy sigmoidoscopy and biopsy

If untreated the case runs a more or less rapid course to the fatal issue which in a patient fifty five to sixty five years of age ensues on an average about twenty-one months after the onset of symptoms. Fæcal obstruction

occurs in about 30 per cent of the cases, being more marked in the chronic forms and in those where the disease starts high up in the bowel on account of the peristalsis causing invagination of the mass. If ulceration is excessive, or the disease situated low down, obstruction is less common invagination being here impossible and peristalsis being expended on the onward passage of the fæces. Exhaustion from hæmorrhage pain sleeplessness, or toxic absorption accounts for most of the fatal results. Septic peritonitis following the perforation of stercoral ulcers above the growth occurs in a few instances.

The diagnosis is made on the result of a careful rectal examination and the passage of blood, or any alteration of the normal bowel habits in an elderly patient symptoms which must never be neglected. 90 per cent. of rectal growths are palpable if care is taken and a routine sigmoidoscopy in these cases will ensure that no growth at the pelvirectal junction is missed. Biopsy should always be performed An antero-posterior X ray of a barium enema may fail to reveal a carcinoma at the upper end of the rectum since the lower end of the sigmoid overshadows this area.

Treatment of Cancer of the Rectum. This consists in the radical measure of excision, the palliative operation of colostomy or treatment by irradiation with or without operation. In assessing the operability of a growth several factors are to be considered

The Stage of the Growth The mere size of the growth in the rectum is no indication of its operability It should be mobile fixation to the prostate or bladder the side walls of the pelvis or the sacrum is generally regarded as a contra indication to radical surgery The posterior vaginal wall can if involved, be removed with the growth A final decision can only be made when the abdomen is opened Secondary deposits in the liver or pelvic peritoneum necessarily render the growth inoperable but enlargement of the nodes in the mesorectum is not to be regarded as a bar to surgery since the enlargement is frequently inflammatory

The Site of the Growth When the examining finger can be passed above a rectal carcinoma, the growth can be removed by the operation of perineal resection an operation with a low mortality whereas a high rectal carcinoma will require some form of combined abdominal and perineal operation. This is a more severe procedure with a higher mortality but removes the nodes along the superior rectal vessels, which the more limited excision fails to do For this reason perineal excision is now seldom employed except palliatively

The Condition of the Patient These operations are easier in women owing to the wider pelvis. In men there is risk of damage to the urethra and bladder Age must be considered in relation to the physique of the patient and the type of operation required. Obesity cardiac and pulmonary disease are unfavourable factors and chronic intestinal obstruction must be relieved by enemata, purges or bowel drainage

While these points are essential in assessing operability present surgical opinion inclines to the removal of the growth whenever possible In the presence of small hepatic metastases or when resection of part or the whole of some adjoining pelvic organ is necessary many hold operation to be justified since death with an inoperable rectal growth *in situ* is usually a miserable end which a palliative colostomy does little to relieve

Types of Operation. A considerable choice of operation is open to the surgeon The following is a brief account of the chief methods employed.

As already stated perineal excision can hardly be considered a radical procedure

Perineal Excision of the Rectum A permanent left iliac colostomy is performed at least ten days before the resection and the lower segment of bowel thoroughly washed out In the male a catheter is tied in before the operation to guide the surgeon as to the position of the urethra With the patient in the left lateral or lithotomy position a purse-string suture is introduced around the anus and tied The perineum is again purified and a racquet incision is made from above the sacrococcygeal junction down to and encircling the anus. The coccyx is disarticulated through this space

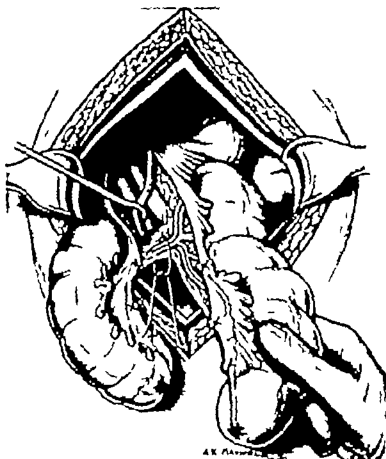


FIG. 44 23. LIGATURE OF THE INFERIOR MESENTERIC ARTERY IN THE ABDOMINOPERINEAL OPERATION

The ureter is drawn aside as it crosses the bifurcation of the common iliac artery

a finger is inserted above the levator ani and the muscle divided close to the side wall of the pelvis on both sides By careful dissection the rectum is separated anteriorly from the urethra and prostate or the vagina. The strong fascia extending forward from the anterior surface of the sacrum is divided, and the rectum stripped forwards from the sacrum Lateral bands of fibro-fatty tissue containing the middle rectal vessels are divided The rectum and anus are now enclosed in a sterile glove and the anterior separation is continued till the peritoneum is exposed. It is opened and divided upwards on either side of the rectum. The mesorectum containing

the superior rectal vessels is divided and ligatured as high as possible The bowel is pulled down and divided between clamps. The upper end is invaginated and the peritoneum sutured to its anterior and lateral surfaces. A large space is left in the perineum. The wound may be completely sutured save for a small drain, or the middle part left unsutured and the space packed with gauze inside a large piece of protective In the male the catheter is left in for three days, in the female a catheter should be passed three times daily till normal micturition is established If packing has been used it is removed on the third day and the wound irrigated daily

Abdominoperineal Resection If necessary this may have been preceded by a caecostomy or colostomy The patient is placed in the full Trendelenburg position and the abdomen opened through the right rectus After ensuring the operability of the growth and the absence of secondaries the small gut is packed off and the inferior mesenteric artery divided between ligatures just below the level of the aortic bifurcation The peritoneum on either side of the rectum is incised downwards to the pelvic floor and the bowel and mesorectum stripped forwards from the hollow of the sacrum. The two peritoneal incisions are joined across Douglas's pouch, the rectum separated from the vagina or prostate and the lateral bands containing the middle rectal vessels divided. The sigmoid colon is now divided between clamps The upper end is brought out to form a terminal colostomy through a small incision in the left iliac fossa while the lower end is ligatured and covered with sterile protective The lower bowel is pushed down into the hollow of the sacrum and the peritoneum united over it. The abdomen is

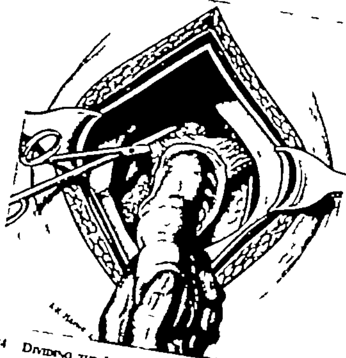


FIG. 48 74 DIVIDING THE LATERAL LIGAMENTS OF THE RECTUM IN THE ABDOMINOPERINEAL OPERATION.



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[King's College Hospital Museum

CARCINOMA OF THE COLON.

1. Annular carcinoma of the sigmoid colon.
2. Annular carcinoma of the transverse colon.

(The drawings do not show the full extent of the resected bowel and mesocolon.)

TO FACE PAGE 1216

closed, the patient placed in the left lateral or lithotomy position and the operation finished by removal of the bowel by the perineal route

Perineoabdominal Resection In this method after a preliminary laparotomy the perineal operation is performed save that the bowel and the mesorectum are not divided The perineal wound is now partly closed over the rectum, which is enclosed in a sterile glove The patient is placed in the Trendelenburg position the abdomen opened and the rectum and lower sigmoid removed through the abdomen leaving a colostomy as in the abdominoperineal operation.

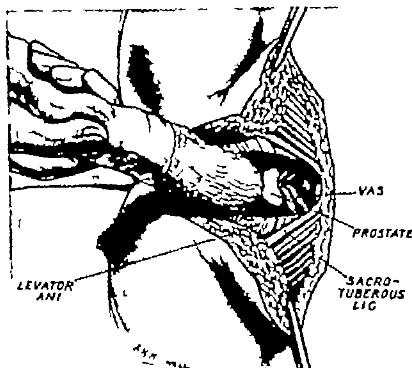


FIG. 48 25 THE FINAL STAGE OF THE ABDOMINOPERINEAL OPERATION.
The pelvic colon and isolated upper part of the rectum are withdrawn from above downwards, from the cavity of the pelvis. Base of bladder prostate and seminal vesicles exposed.

Synchronous Combined Resection The two preceding operations, which are essentially the same in their scope, may be performed by two surgeons working together one in the abdomen the other in the perineum This reduces the operative time and may lessen some of the operative difficulties.

Abdominal Resection (Hartmann's Operation). This consists in the abdominal part of the abdominoperineal resection but after the rectum has been fully mobilized it is divided between clamps deep in the pelvis and the distal stump closed The remainder with the growth is resected and a left iliac colostomy performed. This operation removes the upward lymphatic drainage as for an abdominoperineal resection. It is suitable for *high* rectal growths in subjects who are unfit for a combined method of resection.

Resection and Restoration of Continuity There are several operations which aim at the resection of a rectal growth and the anastomosis of the

sigmoid colon to the rectal stump or the anal canal. They may be performed from the abdomen alone, or by a combination of the abdominal and perineal routes. While the majority of them remove the upward lymphatic drainage of the rectum to the level as *any combined operation*, they obviously cannot make the same wide clearance of the perirectal tissues in the lower part of the operative field. They would appear to be best indicated for the early high growth of low malignancy where it is possible that they may hold out the same chance of cure without a permanent colostomy They are certainly unsuitable for a low rectal growth and though they have a definite place in the treatment of rectal cancer their permanent results are still rather difficult to assess. Local recurrence occasionally occurs at the anastomotic line.

The Choice of Operation. All these operations place a heavy strain upon an elderly patient. Careful pre- and post-operative treatment is *essential. A careful assessment of the patient's general condition, training* in breathing exercises, the use of blood-transfusion during and after the operation the maintenance of the patient's *fluid balance by the intravenous* route until there is evidence that normal bowel tone has returned, these and drugs such as the antibiotics and the sulphonamides, have done much *to reduce the mortality rate during the past decade It is probable that* this is now between 5 per cent. and 10 per cent. and if a high operability rate is to be maintained and many clinics aim at 75 per cent. to 80 per cent., it is doubtful if the mortality rate can be much reduced

It is not possible to dogmatize as to which operation is best A resection should remove an adequate margin of healthy bowel above a growth The average length of bowel removed by a perineal resection is about 20 cm., and this operation is not suitable for a high rectal carcinoma A "combined" operation will remove 35 to 50 cm of rectum and sigmoid, and it is, therefore, the operation for a high rectal growth or where adenomata are present in the rectum and sigmoid above a carcinoma.

A "combined" operation removes the lymphatic drainage of the rectum up to the level of the aortic bifurcation. Considerably less than this is removed by a perineal resection where the mesorectum is divided some 10 to 12 cm lower If the lymph nodes are not involved this wider removal of the lymphatic field has no advantage, but if they are involved (and 40 per cent. *of rectal carcinomas have glandular metastases at the time* of their resection), then it should give a better chance of cure provided the growth has not yet reached the lumbar nodes.

The following is probably a fair summary of present-day surgical thought.

(1) If the growth is high and small, uncomplicated by adenomata or extensive diverticulitis, resection and restoration of continuity should be most seriously considered.

(2) For all other rectal growths the operation which holds out the optimum chance of permanent cure is a "combined" operation however performed.

(3) In a frail and unsuitable subject a perineal resection may be *performed* for a *low* growth or a *Hartmann's operation* for a high growth

(4) Whenever possible an attempt should be made to remove the primary growth. *When hepatic secondaries are present, but small* and the growth is locally operable some form of resection-anastomosis is the ideal

Prognosis Operability varies in different clinics, but is between 50 per

cent and 80 per cent Of those surviving operation some 50 to 60 per cent are alive after five years The prognosis is worse where there is involvement of nodes or where histology has shown a *highly malignant type of growth.*

The Palliative Treatment of Rectal Cancer A left iliac colostomy should be performed not only to prevent obstruction but because it renders the patient more comfortable Radium and X-rays are sometimes used in the treatment of an inoperable growth but they are of doubtful value. As has been mentioned, palliative diathermy is often of benefit to the patient in lessening the constant discharge which is associated with any rectal growth. Presacral neurectomy for the relief of pain has proved disappointing the intrathecal injection of alcohol in an attempt to affect the sensory sacral nerves gives better results, though it may cause difficulties in micturition in elderly men Chordotomy the division of the antero-lateral tracts of the spinal cord, is a more severe measure but it has proved an effective operation in certain cases.

Pelvic Evisceration There are occasional cases where local extension of the growth to the prostate and bladder or to the uterus and bladder is unassociated with distant metastases In such patients it is sometimes possible to perform a complete evisceration of the pelvis, implant the ureters into the sigmoid and leave the patient with a " wet " colostomy for which a special colostomy bag is required. The operation is severe and the choice of patient requires discretion

Carcinoma of the Anus. A squamous carcinoma may arise in the anal margin or anal canal, the former being more common in men, the latter in women (Gabriel) These form about 3 per cent. of the malignant growths of the rectum and anus. Occasionally it may start in a chronic fissure, in skin for long affected by pruritus ani or following repeated X-ray therapy for the latter condition. It appears as an ulcerated nodule, an indurated ulcer or a warty growth. Biopsy enables a certain diagnosis to be made.

The lymphatic drainage of this region is to the inguinal lymph nodes but growths affecting the anal canal may drain also into the lymphatic system of the rectum.

Treatment Early small cancers of the anal margin may be treated by efficient surgical excision followed by a Thiersch graft or healing by granulation. The inguinal lymph nodes may be kept under observation and if necessary given X rays, or treated by block-dissection. In such cases the primary growth may also be treated by interstitial radium needling or by X rays.

For more advanced cases of the anal margin and anal canal either a perineal or abdominal perineal resection will be required.

Section Seven

GENITO-URINARY SURGERY

J G SANDREY   STANLEY G CLAYTON
SELWYN TAYLOR

Chapter 49

THE KIDNEYS

Introduction

The kidneys are situated on either side of the lumbar spine and extend from the eleventh rib above to midway between the last rib and the iliac crest below the right kidney being somewhat lower than the left, owing to the presence of the liver The hilum is situated opposite the spinous process of the first lumbar vertebra, and the upper ends of the organs are nearer to the spine than the lower

Exposure. The kidneys may be approached by two chief routes, *viz.* the lumbar and the abdominal.

The *lumbar incision* commences at a point corresponding to the outer border of the erector spinæ, ½ inch (1 cm) below the last rib, extending downwards and outwards in the direction of the fibres of the external oblique towards the anterior superior iliac spine. The posterior portions of the abdominal muscles and the fascia lumborum are divided seriatim and the fatty tissues surrounding the kidney is thus easily reached and opened. Variations of the incision must be made to suit the particular requirements of the case. Better access can be obtained (*e g* for large renal tumours) by the subperiosteal resection of one or more of the lower ribs.

In the *abdominal operation* the kidney is exposed from the front, usually through a free paramedian or transverse incision the peritoneal cavity is opened or not, as may be thought necessary If the peritoneum is opened, the colon is displaced inwards and held aside, as also the other intestines by abdominal cloths the peritoneum covering the posterior abdominal wall is incised to the outer side of the colon, and the organ thus reached When, however the kidney is enlarged, it may be unnecessary to open the peritoneal cavity as the colon and other peritoneal contents are displaced inwards.

Examination of the Kidney

Manual Examination. This is best made with the patient on the back, with the legs raised, the head supported by a pillow and the mouth open. The surgeon, kneeling or standing at the side of the couch, places one hand under the loin and presses it upwards, while the other is gently but firmly pressed backwards in the lumbar region, especially during expiratory movements. Unnatural mobility enlargement or displacement downwards of the organ will be thereby detected, as also irregularities in outline or modification of tension.

An *enlarged kidney* is recognized by the following general characters A swelling is noticed in the loin which is shaped more or less like the kidney with its outer border rounded, a notch being occasionally though rarely

felt on the inner border The flank is always dull on percussion the note remaining unaltered whatever the patient's position, intestine never finds its way behind the tumour The passage of the colon in front of the kidney often gives rise to a band of resonance over its anterior surface the bowel, however soon gets pushed aside inwards as the enlargement increases. On the right side it is not unusual for the renal dulness to be continuous with that due to the liver there is always distinct resonance below and to the inner side of the mass towards the pelvis, thereby distinguishing it from a pelvic swelling. The mass moves on respiration though less distinctly than the liver or spleen

On the left side it has to be distinguished from an enlarged spleen the *latter viscus hugs the anterior abdominal wall and has no gut in front of it*, while the loin is usually resonant.

Radiography Examination of the kidneys and ureters is often necessary in order to ascertain whether a calculus is present Areas of calcification in the kidney sufficiently dense to cast a shadow in X-ray films may be observed in cases of renal tuberculosis or less commonly in tumours or cysts. A good film should outline the lower half of the kidney and when the organ is abnormally enlarged as in cases of tumour or gross hydronephrosis, its size can often be estimated with accuracy from the study of a radiogram

There is now not much difficulty in making certain of the presence or absence of a stone in the kidney or ureter although the permeability to the rays of a pure uric acid calculus still renders mistakes possible. Oxalate calculi or those formed of phosphates, cystine, or of a mixed composition, ought in all cases to be demonstrable, and their number, site, and position ascertainable

The differential diagnosis of the shadows of calculi from those produced by other conditions is rendered easier by good quality skiagrams. In most cases it is possible to show the outline of the kidney as well as the stones contained in it, and one can thus eliminate the shadows produced by calcified mesenteric glands, bowel contents or appendicular concretions. Gall stones are occasionally visible and this may lead to a mistake in diagnosis. Calcified caseous deposits in old-standing tuberculous kidneys also cast shadows but they are distinguished from calculi by their more diffuse outline and want of definition together with the clinical history It is necessary for the radiographer and clinician to work together only coming to a decision after consultation

Lateral films are often useful in localizing shadows in the renal area as a renal calculus will overlap the bodies of the lumbar vertebræ whereas shadows in the bowel, gall-stones etc., will lie much further forwards.

The positive diagnosis of ureteral calculi is sometimes more difficult, as they have to be distinguished from phleboliths, calcified pelvic nodes appendicular concretions, bowel contents, calcified appendices epiploicæ and calcified uterine fibroids. It may be necessary to pass an opaque bougie up the ureter and repeat the examination before a diagnosis can be made Phleboliths are nearly always circular and frequently multiple they are due to localized areas of calcification in the deep pelvic veins. Calcified inguinal nodes are easily recognized by their superficial position on stereoscopic examination. Bowel contents are excluded by repeating the examination after effective purgation and indeed this is a course which should always be followed except in cases which are absolutely characteristic Calcified

fibroids simulating ureteral or vesical calculi can generally be detected on clinical examination.

The preparation of the patient for the examination is of great importance especially in one of heavy build The intestine must be empty in order to get good results and the patient should if possible be kept on light diet for some days previously A course of purgation for two or three days will ensure an empty bowel especially when the patient is ambulant. Pituitrin or pitressin followed by the passage of a flatus tube are useful when distension is present in bedridden patients.

A good deal of useful information can be obtained as to the physical condition of the ureter and of the calyces and pelvis of the kidney by the procedure known as ascending or retrograde pyelography which consists in injecting through a ureteral catheter a solution of sodium bromide (20 per cent.) or of sodium iodide (15 per cent.) up the ureter so as to fill the



FIG. 49 1 THE PELVIS OF THE NORMAL KIDNEY IN DIASTOLE AND SYSTOLE.
A. Pelvis in diastole, with major and minor calyces well defined.
B. Pelvis in systole, minor calyces not visible. Narrowing of communicating channels and contraction of pelvis.

pelvis, and then taking a skiagram A normal pyelogram is represented in Fig. 49 1 and it will be noted that the shadows of the calyces are concave or cup-shaped, owing to the projection into them of the pyramids. The pelvis of a normal kidney has a capacity of 5 to 8 ml. of solution, but this is much increased in pathological conditions, such as hydronephrosis. The minor calyces tend to become dilated (or "clubbed") and their outline becomes ill-defined and fuzzy By this means it is easy to detect kinks or other abnormalities in the shape of the ureter and its attachment to the pelvis, also varying degrees of pelvic dilation (hydronephrosis), and irregularities in the shape and size of the kidney itself Doubtful shadows may also be shown to lie outside the renal or ureteric region by this means. Owing to the ease with which rupture of the calyces can be caused by over-distension retrograde pyelography is preferably carried out in the conscious patient in children, where this is not possible, great care must be exercised

Radio-opaque drugs, such as iodoxyl or diodone which contain a high percentage of iodine, can be given intravenously and are excreted by the kidneys in sufficient concentration to show the outline of the kidney calyces and pelvis, and are very useful when cystoscopy is not possible or when it

is desired to compare both kidneys. Pictures are usually taken five minutes, ten minutes, and thirty minutes after injection, some indication of renal function is obtained by noting the time of excretion and the density of the shadow The bladder outline (cystogram) will also be visible in most cases, pictures being taken at thirty minutes when the viscus is usually filled, and after micturition.

Renal arteriography and peri-renal air insufflation are methods requiring specialized techniques which have recently been developed for the investigation of certain diseases, particularly space-occupying lesions of the kidneys and adrenals.

Examination of Renal Function

No serious operation on the urinary organs ought ever to be undertaken in the absence of more or less satisfactory knowledge as to the functional capacity of the kidneys. When the surgeon is considering the question of removing one kidney it is not sufficient merely to know that a second kidney exists he must be assured that it is capable of "carrying on" efficiently if left to itself In conditions, moreover of the lower urinary organs which may be associated with secondary changes in the kidneys, serious operations should not be undertaken unless the quality of the renal function has been estimated Many a patient has lost his life after prostatectomy because of the fact that his damaged kidneys are incapable of standing the strain of a severe operation on the urinary tract.

The tests for the determination of renal efficiency are complicated and at present cannot be relied on absolutely Their very multiplicity suggests the uncertainty that still exists as to their value, and the differences of opinion as to their respective merits are considerable.

Amount and Quality of the Urine Tests should be carefully made in all cases of disease of the kidneys or of the urinary organs where it can be of any significance. The specific gravity should be regularly measured, and the amount of output of urea a persistent low specific gravity and a defective urea content are always danger signals The amount of urine passed apart from a knowledge of its specific gravity is no index of the efficiency of the renal secretion. The amount of urea output is little guarantee, apart from a knowledge of the character of the food taken moreover it does not suggest or give any clue as to the capacity of the kidneys to deal with an emergency nor does it show the amount of urea still existing in the blood.

Urea Concentration Test. This test is performed to discover the capabilities of the kidneys to react to a stimulus. All fluid is withheld from the patient for six hours and then a dose of urea (15 g. in 100 ml. of water) is administered The volume of urine passed hourly for three hours is measured and the percentage of the urea content, as compared with the dose given, carefully investigated. If the urea in the urine exceeds 2 5 per cent., the kidneys may be considered to be acting adequately If the amount is between 2 5 and 2 per cent. the renal function is probably sufficient, but it is likely that some damage to the secretory apparatus is present, and it may be desirable to estimate, in addition the amount of urea in the blood If the urea content is below 2 per cent., the kidney function is probably unsatisfactory Excessive excretion of urine (diuresis) somewhat vitiates these figures and that must also be taken into account

Diminution in or loss of the functional activity of the kidneys results in nitrogen retention and other profound disturbances in the blood chemistry. This leads sooner or later to the development of the clinical state known as *uræmia* which may have a gradual or sudden onset and be represented by a multiplicity of varying symptoms. Drowsiness, headache, vomiting and convulsions are probably the most characteristic features, while delirium, various paralyses and asthmatic attacks may appear. The symptomatology is generally confused by dehydration, cardiovascular disease and urinary infection which are frequently associated with renal disease.

Nephrectomy

Nephrectomy is performed for the following conditions (*a*) For tuberculous disease when unilateral (*b*) for calculous pyonephrosis, when the renal parenchyma is disintegrated (*c*) for hydronephrosis, when palliative measures or drainage have failed to give relief (*d*) for malignant disease (*e*) for certain injuries of the kidney as this is the only sure means of controlling severe renal hæmorrhage and (*f*) for some cases of ruptured ureter and fistula from pelvis or ureter when attempts at closure have failed.

Before undertaking the excision of any kidney however diseased it is essential that the surgeon should satisfy himself as to the existence of the other and also if possible ascertain that it is capable of undertaking the increased duties which will subsequently fall upon it.

Nephrectomy may be undertaken through the abdomen or through the loin but sundry combinations or modifications of these operations have been recommended by various authorities.

Abdominal Approach. This is sometimes utilized for the removal of large renal tumours or to gain access to the isthmus of a horseshoe kidney. *The peritoneum must be carefully protected from septic contamination,* when the pelvis and the upper part of the ureter are distended with decomposing pus. The colon and peritoneum are displaced inwards the kidney is then freed from its adhesions to surrounding tissues, the surgeon endeavouring to keep outside its true capsule, but inside the layer of condensed perinephric tissue. Special precautions must be adopted in dealing with the deep aspect of the kidney particularly on the right side where it is occasionally adherent to the inferior vena cava. The mass is now lifted from its bed, and its pedicle, consisting of the ureter and renal vessels isolated. These latter are secured separately by ligature and divided a clamp being applied to the distal ends. The wound in the abdominal parietes is closed in the usual way provision for drainage being made either through the loin or from the front.

Lumbar Approach. This gives the most direct access to the kidney and pedicle and can be regarded as the standard method to-day. The organ is exposed by the incision already described, enucleated from its surroundings and the pedicle dealt with as in the abdominal operation.

Should it be desirable to include the ureter in the scope of the operation, the incision may be prolonged into the groin in the direction of the fibres of the external oblique and the peritoneum and its contents pushed forwards by this means it can be traced down almost to the bladder. It may be desirable however to delay the excision of the ureter to a later date effecting it through an anterior incision as for a ureteral calculus.

tumours which stretch the abdominal walls or rapid emaciation whereby the perinephric fat is absorbed.

Symptoms A movable kidney is often discovered by accident and may be entirely free from symptoms. In some cases the patient comes under observation because she has observed a movable lump in the abdomen, which on handling is painful, the pain being often associated with nausea and vomiting. In other cases pain and vomiting bring the patient under observation the doctor discovering the movable kidney The pain is referred to the back, or perhaps shoots along the ureter to the groin testis, or labium majus. Vomiting is a significant sign and the surgeon should never omit to examine the loins in cases of obstinate vomiting *with no apparent cause*. Periodical exacerbations of these symptoms, with a temporary diminution of the amount of urine, result from kinking of the ureter (Dietl's crises) sudden relief *followed by an increased flow of urine, indicates that the organ* has returned to its normal situation. On examining the abdomen, a movable tumour can often be observed with ease if the abdominal parietes are not *loaded with fat, and on manipulation* pain and *vomiting* may be induced

The patient is usually of a neurotic type in whom evidence of displacement of other abdominal viscera is often found, so that the detection of a movable kidney does not necessarily explain the whole case, or indicate operation. After operations for movable kidney the symptoms (pain, vomiting, etc.) have often been known to persist, even though the organ remained anchored to the abdominal wall.

Treatment In the great majority of cases operation is not required, and, indeed it is usually unwise to tell the patient that such a condition is present. In debilitated subjects a rest-cure in bed with abdominal and general massage and an abundance of milk and fatty foods will do much to anchor the kidney and improve the general condition. The wearing of a carefully fitted kidney support will often afford complete symptomatic relief This consists of an air-cushion fitted into an abdominal belt the cushion should be triangular in shape, its sides corresponding to the costal border the inguinal ligament, and the linea semilunaris it is put on while lying down and for choice with the pelvis raised.

Nephrorrhaphy or *nephropexy* is the name applied to the operation for fixing the kidney It is obvious that a rounded body like the kidney with a smooth fibrous capsule is not easily fixed and the more so since the renal parenchyma has great absorbent powers, so that sutures, even of silk, passed through its substance are readily disintegrated and absorbed hence although the kidney may seem to be efficiently immobilized at the completion of the operation, it readily becomes loose again. In any case, this operation has not stood the test of time and, since the results have been uniformly disappointing, is now seldom performed.

Injuries to the Kidney

Injuries to the kidney may be open or closed.

Open Wounds. These are rare in civil life and are usually due to stab-wounds of the loin. In modern warfare they are more common, renal damage occurring in about 7 5 per cent. of wounds requiring abdominal exploration. They are often complicated by involvement of abdominal viscera or intrathoracic structures. The wound of entry is seldom in the loin but is more likely to be found in the thoracic or abdominal region,

(1) They may be the underlying cause of urinary infection or stone formation.

(2) They may cause mistakes in diagnosis or unexpected difficulties at operation.

(3) They may cause difficulty in the interpretation of pyelograms.

Renal Ectopia. This is fairly common, the kidney lying at a lower level than usual, sometimes even below the brim of the pelvis (pelvic kidney). Here it may cause mistakes in diagnosis and be mistaken for a pelvic tumour An ectopic kidney is distinguished from a ptosed kidney by the fact that it has a short ureter The suprarenals retain their normal position and do not move with the kidney

Cystic disease, hydronephrosis and hydroureter may also occur congenitally and will in turn be described below

Movable and Floating Kidney The normal kidney is not a fixed organ, but moves up and down on respiration although usually this movement cannot be detected on palpation. It is therefore necessary to define as precisely as possible what is meant clinically by the terms "movable" and "floating" kidney Three stages of abnormal mobility may be described (*a*) A *palpable* kidney is one the lower half or more of which can be definitely felt on deep inspiration. (*b*) A *movable* kidney is one in which the examining hand can define the upper end of the organ and can restrain it from returning to its old position during expiration. (*c*) A *floating* kidney is one which can be moved freely about the abdomen in all directions, and even across the middle line in some cases. Formerly this last term was applied to a supposed congenital lesion, in which the kidney was attached to the posterior abdominal wall by means of a mesentery it is more than doubtful whether such a condition exists.

Marked mobility will produce secondary kinks in the upper ureter but when hydronephrosis is present it is often difficult to tell whether this is due to an obstruction or whether the increased weight of the hydronephrotic kidney has caused it to drop

Movable kidney occurs more frequently in women than in men (10 to 1) and more often on the right than on the left side (12 or 13 to 1), partly because the renal vessels are longer on this side than on the other partly because the descending colon is more fixed than the ascending, and partly because of the pressure of the liver

Causes The kidney is placed between the layers of the perinephric fascia which in turn are derived from a splitting of the fascia transversalis. In children this perinephric capsule is attached closely to the kidney front and back without any intervening fat but as development proceeds, fat is packed in around the kidney in increased amount, and hence in stout subjects the perinephric capsule is considerably distended and the kidney firmly supported In addition to this, however the tension of the peritoneum, the maintenance of the intra-abdominal pressure and the support of the muscular abdominal parietes have much to do in keeping it in place. Anything that seriously modifies these three factors may lead to displacement and mobility of the organ. Parturition accounts for some cases—first, because of the sudden diminution of the intra-abdominal pressure secondly owing to the resulting pendulous and relaxed state of the abdominal muscles, especially if the patient does not exercise these muscles and help them to regain their original tone. It may also follow the removal of large abdominal



[King's College Hospital Museum

LARGE BRANCHED RENAL CALCULUS.

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missiles frequently travelling great distances in the body before they strike the kidney. Renal wounds are generally classified into two groups (1) those involving the hilum and (2) those involving the parenchyma. Hilar wounds may damage either the renal vessels causing severe hæmorrhage or the renal pelvis, causing urinary extravasation. Parenchymal wounds vary from superficial contusions of the cortex to complete pulping of the organ. Symptoms will vary with the anatomical nature of the lesion but hæmorrhage is the predominant feature in most cases. Hæmorrhage may be intra-pelvic (hæmaturia), intraperitoneal, or peri-renal.

All penetrating wounds of the kidney should be explored as soon as possible in order to prevent infection (by removing foreign bodies and providing free drainage) and to control hæmorrhage. The only exception to this rule is in the case of a clean perforating bullet or stab wound of the loin (missile not retained) which has not caused severe renal hæmorrhage.

Before operation it is essential to determine the state of the undamaged kidney since nephrectomy may be necessary. This information can best



FIG 49 4. RUPTURE OF THE KIDNEY (*King's College Hospital Museum.*)

be gained by intravenous pyelography but, where X ray facilities do not exist other methods such as chromocystoscopy or palpation of the opposite kidney at operation, may be less confidently employed. Treatment consists of nephrectomy in most cases but conservative procedure (ligation of severed vessels, suture of wounds of the pelvis, evacuation and drainage of perirenal effusions) may be carried out under special circumstances.

Closed Wounds. In contusions of the kidney the mechanism, the resulting lesion and in most cases, the treatment, differ widely from the open type of wound. The usual cause is a kick or blow on the abdomen, "run-over" accident, air crash or industrial accident. Whatever the cause the mechanism is the same in every case the kidney being crushed against the unyielding posterior abdominal wall by a force transmitted through the soft tissues of the anterolateral aspect of the lumbar region. the direction rather than the severity of the force will determine the extent of the renal lesion. Subcutaneous ruptures show a remarkable uniformity in their appearances, one

or more fissures radiating out from the hilum in the direction of the medullary rays. The softer medulla always tends to be damaged more extensively than the cortex but in severe injuries the fissure may involve the entire thickness of the kidney so that the organ is bisected or one or other pole detached. Associated lesions are much less common than in open wounds and intraperitoneal complications are confined for the most part to ruptures of solid organs (liver or spleen) in a small proportion of cases. As the kidney is the most vascular organ in the body it follows that the most prominent symptom of damage to the parenchyma is always *hæmorrhage* and as the lesion tends to involve the medulla rather than the cortex the bleeding will be *intrapelvic* and give rise to hæmaturia in the vast majority of cases. Sometimes the bleeding is external when a perirenal hæmatoma rapidly appears. In complete tears both types of hæmorrhage may occur simultaneously. Profuse bleeding down the ureter into the bladder may give rise to clot retention. Shock is nearly always present and varies with the severity of the lesion and the amount of hæmorrhage.

The diagnosis is not difficult and it is safe to assume that a subcutaneous lesion is present when there is evidence of renal hæmorrhage (hæmaturia or perirenal hæmatoma) and local tenderness following abdominal trauma. Intravenous pyelography should be carried out as soon as shock has been dealt with.

Treatment. This should in the first instance be carried out along expectant lines. Absolute rest in bed, adequate doses of morphine and close observation are all essential. Complete cessation of renal hæmorrhage generally occurs within a few days and a rapid spontaneous cure follows in most cases. During the first week a constant watch should be kept on the urine, the pulse, the blood pressure and (by repeated light palpation of the loin) the kidney itself. Operative treatment is necessary in about 10 per cent. of all cases, the chief indication being hæmorrhage (primary, reactionary or secondary) of sufficient severity to endanger life. Coexisting intraperitoneal lesions, such as rupture of the liver or spleen, may require laparotomy and this will afford an opportunity to inspect a damaged kidney. In most cases a perirenal hæmatoma will absorb rapidly but drainage will be indicated if signs of infection develop.

Patients treated conservatively should always be left in hospital for at least three weeks and the process of repair carefully checked by means of intravenous pyelography. In some cases it will be found that cicatrization has caused obstruction to the free drainage of the renal pelvis and this may have to be corrected to avoid complications later on.

Injuries to the Ureter

Injuries of the ureter are more often due to operative trauma than to any other cause.

Subcutaneous Rupture. This may follow direct violence (*e.g.* severe crushing injuries of the abdomen), the lumbar segment being usually involved. The deep position of the ureter, its elasticity, the protection afforded by the bony pelvis and the "cushioning" effect of the psoas muscle behind make this type of injury exceedingly uncommon. For similar reasons the ureter is rarely involved in abdominal wounds. Such injuries, when they do occur are likely to be complicated by damage to overlying viscera and are often fatal. Rupture or perforation of the ureter gives rise to extravasation of

bladder ureterocele vesical calculus neoplasms, obstruction to the intra mural part of the ureter from hypertrophy or fibrosis of the bladder wall are among the commoner causes (*c*) *Urethral obstructions* may be due to

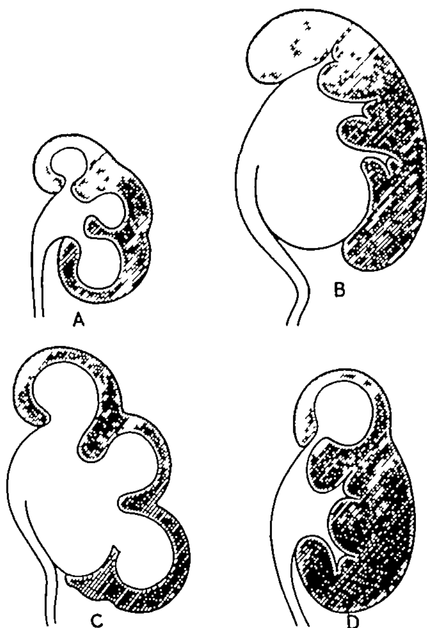


FIG. 49 5 TYPES OF HYDRONEPHROSIS.

A. "Renal" type. Note dilatation of calyces at the expense of the kidney
B. "Pelvic" type. Note high insertion of the ureter Renal atrophy is slight.
C. "Total" hydronephrosis. Note atrophied lobulated kidney
D "Partial" hydronephrosis (hydrocalycosis).

enlargements, neoplasms, inflammations and calculi of the prostate, stricture, neoplasm, calculus or congenital flaps or valves of the urethra. In the latter group the hydronephrosis is bilateral and is usually associated with hydro-ureter

urine in the retroperitoneal cellular tissues, a condition which, in its earlier stages, is often difficult to diagnose. Infection rapidly takes place leading ultimately to widespread retroperitoneal cellulitis. Treatment consists in free drainage of the extravasation and, because of the frequency of ascending infection, nephrectomy is necessary in most cases to effect a cure. Repair of the ureteral lesion is rarely possible because of local infection

Operative Injuries. *The pelvic segment* may be clamped or ligated in the performance of abdomino-perineal resection of the rectum, abdominal or vaginal hysterectomy or during the removal of bladder growths or diverticula. An escape of urine from the abdominal wound or per vaginam a few days after operation is usually the first indication of ureteral injury and a ureteric catheter will be arrested a few centimetres above the bladder The lesion, even when partial, proceeds rapidly to stricture-formation with dilatation and finally infection of the kidney above The treatment in most cases is nephrectomy but it is sometimes possible to effect end to-end union, to reimplant the ureter into the bladder or to transplant it into the bowel. Nephrostomy may be necessary when renal failure is threatened (e g bilateral injury or impaired function on the uninjured side), and in these cases attempts at repair are postponed until the patient s condition improves and the blood urea returns to normal

The *upper end* of the ureter may be damaged or inadvertently detached from the renal pelvis during the course of renal operations, especially those for the removal of large renal calculi When overlooked this may give rise to a urinary fistula, or else severe obstruction at the ureteropelvic junction may arise later from cicatrization. Local repair is sometimes possible but more often nephrectomy is necessary

Lastly the ureter may be perforated from *within* by ureteric catheterization, by over vigorous dilatation of a ureteral stricture or by forcible attempts at endoscopic removal of an impacted ureteric calculus.

Hydronephrosis

The term hydronephrosis (or more accurately *pyelectasis*) simply means dilatation of the renal pelvis. The condition may involve the whole renal pelvis (total hydronephrosis) or may be more localized (partial hydronephrosis) it is sometimes associated with similar dilatation of the ureter (hydroureter or ureterectasis) Partial hydronephrosis may be confined to the calyces (renal hydronephrosis) or the extra-renal pelvis alone may be involved (pelvic hydronephrosis)

Ætiology Two clinical types are distinguished obstructive and non-obstructive.

Obstructive (Secondary) Hydronephrosis This follows any obstruction severe enough to prevent the free flow of urine from the renal pelvis. Dilatation always progresses more rapidly when the obstruction is partial or intermittent (e.g by calculus) than when it is complete (e g after accidental ligature). An obstructive hydronephrosis is always predominantly renal in type, the calyces undergoing dilatation while the extra renal pelvis remains more or less normal (Fig. 49 5 A) The obstruction may be found in the ureter bladder or urethra (a) *Ureteral obstructions* may arise from without (e g pressure of neoplasms, inflammatory adhesions and possibly aberrant vessels) in the wall of the ureter (e g kinks, strictures, neoplasms) or from within the lumen (e g calculi, blood-clot, tumours). (b) *In the*

bladder ureterocœle vesical calculus neoplasms, obstruction to the intra mural part of the ureter from hypertrophy or fibrosis of the bladder wall are among the commoner causes. (*c*) *Urethral obstruction* may be due to

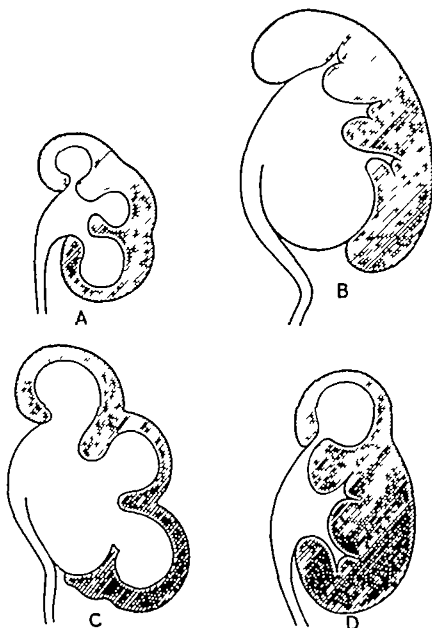


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D "Partial" hydronephrosis (hydrocalycosis).

enlargements, neoplasms, inflammations and calculi of the prostate, stricture, neoplasm calculus or congenital flaps or valves of the urethra. In the latter group the hydronephrosis is bilateral and is usually associated with hydro-ureter

The part played by aberrant renal vessels and nephroptosis in the ætiology of hydronephrosis is not always easy to determine and the fact that these abnormalities frequently exist without any tendency to dilatation of the renal pelvis makes it unwise to assume that these conditions are necessarily related to hydronephrosis when the two are associated

Non-obstructive (Primary or Idiopathic) Hydronephrosis This type is predominantly pelvic (Fig. 49 5 B) and is not associated with any definite obstruction. The ætiology is obscure but seems likely that it is due primarily to a disturbance of the normal peristaltic action of the pelvis and ureter ("neuromuscular dysfunction") the upper end of the ureter failing to relax when the pelvis contracts, thus preventing the escape of urine from the distended renal pelvis The close resemblance between idiopathic hydronephrosis, megacolon and idiopathic dilatation of the œsophagus should be noted. Idiopathic hydronephrosis is often bilateral.

Pathology The essential pathological difference between renal and pelvic hydronephrosis is that in the former the dilatation takes place within the kidney at the expense of the renal parenchyma, whereas the latter is extra renal and produces less severe renal damage. In the later stages of pelvic hydronephrosis, however the grossly distended renal pelvis will itself act as an obstruction and progressive dilatation of the calyces will then take place leading to the formation of a total hydronephrosis (Fig. 49 5 C). This process is accelerated by the formation of secondary valves and kinks of the distorted upper ureter Finally the kidney becomes converted into a huge cystic lobulated shell containing dilute urine the lobules correspond to dilated calyces and these are separated by fibrous septa which represent the original columns of Bertini.

Termination. Dilatation is progressive and will go on indefinitely unless the cause is removed or some complication intervenes. The amount of recovery after relief of the obstruction will depend partly on the degree of damage to the parenchyma and partly on the degree of hypertrophy of the opposite kidney Infection is the commonest complication and will result in the formation of a pyonephrosis next in order of frequency is stone-formation and in many cases infection and stone are associated. Calculi forming in a dilated pelvis are generally multiple Rupture of the sac may occur spontaneously or after a trivial injury

Clinical History This varies considerably with the method of onset and the cause of the trouble. Frequently all that happens is a painless enlargement of the affected organ if both kidneys are involved there may be at first some increase in the amount or urine secreted which is pale limpid and of a low specific gravity after a time the quantity diminishes and finally anuria and uræmia follow especially if septic changes supervene as is so commonly the case When only one kidney is affected the excretion may remain normal in quantity and quality owing to compensatory hypertrophy of its fellow An elastic swelling, fluctuant if of considerable size is produced and presents all the physical signs of a renal tumour

Symptoms These are more often due to the causative agent rather than to the disease itself pain from a renal stone or bleeding from a growth. There may be a history of occasional attacks of acute pain and swelling on the affected side the swelling and pain disappearing after voiding a large quantity of pale urine this is known as *Dietl's crisis*

The symptoms due to the disease itself are pain which may be a dull

ache due to the size of the swelling or more acute in the stage when outflow is completely blocked Vomiting may be due to the pain or occur as a result of early uræmia when it is associated with dry tongue, thirst and other signs of early renal failure. True polyuria may occur and cause increased frequency of micturition which may however be of reflex origin. Hæmaturia occurs in some cases for which no cause can be found

Sometimes the disease is quite *symptomless especially in the bilateral* cases due to obstruction in the lower urinary tract. In some instances a swelling in the loin a generalized enlargement of the abdomen or vague abdominal discomfort may cause the patient to seek medical advice.

Lastly the symptoms arising from the disease may be those due to a complication, such as infection calculus or rupture of the sac.

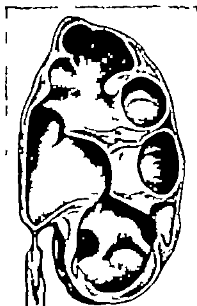


FIG. 49 6. OBSTRUCTIVE HYDRONEPHROSIS, RENAL IN TYPE DUE TO A STRICTURE AT THE UPPER END OF THE URETER.
Note marked renal atrophy

Investigation. After routine abdominal, rectal and vaginal examination and urinalysis, with investigation of signs of early renal failure, X ray pictures should be taken these may show stones or calcified abdominal nodes. Cystoscopy may reveal the presence of an enlarged prostate, ureterocele, or the orifice of a bladder diverticulum. Both ureters should be catheterized, the site and nature of any obstruction being noted the rate of flow from the affected side will be very rapid, and it may be possible gently to aspirate many ml. by a syringe attached to the catheter The specimen collected from each ureter should be examined for organisms and pus cells and the urea percentage of the two sides compared. Pyelography will reveal the degree of hydronephrosis, any filling defect due to growth, and confirm the level of ureteric obstruction. Before instituting treatment, the integrity of the other kidney must be established.

Treatment. The treatment of hydronephrosis should in the first place be directed to the removal of the cause, if practicable, and where obstruction exists in the prostrate or urethra, no other treatment is usually necessary

In some cases of hydronephrosis due to malformation of the upper end of the ureter it is possible to relieve the obstruction in various ways, e g the pinhole orifice of the ureter may be exposed within the pelvis and divided longitudinally with subsequent stitching open of the margins.

Various operations have been devised to diminish the size of the pelvis (*pyeloplasty*) and to improve its drainage (*uretero-pyeloplasty*), their multiplicity indicating that none is entirely successful. These procedures fall into two groups first when the anastomosis is supported by a splinting ureteric catheter (Davis and Von Lichtenberg operations) and secondly where no foreign body is employed (Hynes-Anderson and Foley Y-plasty operations) These plastic operations must only be performed if the urine of that kidney is sterile. Stenosis of the lower end of the ureter may be treated by transplanting the end proximal to the obstruction into the bladder

Renal sympathectomy is carried out through the usual lumbar incision and the vessels and pelvis stripped of their sympathetic nerve supply This will relieve the pain caused by hydronephrosis, although it is unlikely to have any effect on the size of the renal pelvis.

It should be pointed out that the numerous "conservative" operations performed for idiopathic hydronephrosis (sympathectomy ureteroplasty pyeloplasty etc.) have not been uniformly successful and are unlikely to be until the pathogenesis of this condition has been clarified.

In the later stages, especially where suppuration is threatening or present, nephrectomy will often be required

In bilateral cases with renal failure, double nephrostomy is necessary This may be permanent or temporary as in some cases with improvement of the patient's condition the obstruction may be dealt with and the nephrostomy closed.

Pyogenic Infections of the Kidney and Ureter

Pyogenic infections of the kidney and ureter may develop from many distinct sources and give rise to several allied though distinguishable, clinical conditions.

(1) The infective material most frequently reaches the kidney from the blood. Oral and other types of sepsis can often cause blood contamination bacteria can readily find their way from the capillary blood-stream in the glomeruli into the renal tubules and give rise to an infective nephritis which may spread to the pelvis. Similarly a pyæmic embolus may determine an infective lesion of the renal parenchyma, ending either in a single large localized abscess, or in many scattered foci of suppuration. In cases where a focus of disease pre-exists in the kidney e g stone, tubercle, or cancer a secondary pyococcal infection adds gravely to the severity of the symptoms.

(2) When once the kidney substance is involved, infection tends to spread to the pelvis, causing a suppurative pyelitis (or inasmuch as the renal parenchyma is already invaded, a suppurative pyelonephritis) thence down the ureter to infect the lower urinary passages and perhaps the genital tract in the male (descending infection).

(3) A common method of origin consists in pyogenic organisms spreading upwards from the bladder to the ureter and kidney This may arise from a primary cystitis, but is seen most frequently in the affection which used to be termed "surgical kidney" and follows in the train of many

diseases accompanied by cystitis, e g stricture of the urethra enlarged prostate, stone in the bladder, etc. It will be remembered that the ureter passes through the bladder wall in an oblique direction and is guarded by strong sphincteric muscular fibres Thereby the spread of infection upwards is rendered more difficult, except in some cases of rigid open ureter as in tuberculosis, when it may be that secondary infection reaches the kidney by the lumen of the ureter It may be (but has not been proved) that in cases of "ascending pyelonephritis" the infection reaches the kidney by peri ureteric lymphatics from the bladder or even in some cases by the blood-stream and is really hæmatogenous with the bladder as the primary focus When the phenomena caused by this infection from below are limited to a suppurative condition it is known as an *ascending pyelonephritis* When an element of distension is added to the above due to obstruction then the distended suppurating kidney is known as a *pyonephrosis*

(4) *Sometimes* the infection reaches the urinary passages from neighbouring organs, as in disease of female cervix, rectum or even of the appendix in the former the bacteria are probably disseminated by the lymphatics in appendicitis or diverticulitis an abscess may open into the kidney or ureter or the latter structure may be involved in the inflammatory process. In the female, infection may easily spread along the short urethra from the vulva

The organisms usually present are staphylococci streptococci or *Esch. coli* which as will be seen later is very frequently associated with inflammation of the bladder *Proteus Ps aeruginosa* and *A aerogenes* are more rarely found and are nearly always introduced from without as the result of operations on the urinary tract or drainage by tubes or catheters.

Pyelitis. This is a clinical rather than a strictly pathological term applied to an inflammation of the renal pelvis. It is nearly always due to infection by the coli-typhoid group of bacteria and is hæmatogenous in origin. The lining membrane becomes congested and thickened, secreting a muco-purulent, or even purulent, discharge. Owing to the swelling of the mucous membrane, the lumen of the ureter is encroached on and a certain amount of distension of the pelvis and calyces (hydronephrosis) follows. The renal parenchyma is always more or less involved in the process (pyelonephritis). The inflammation is apt to spread down the ureter to involve the bladder and sometimes the genital tract in the male.

The chief predisposing causes are constitutional and local. *Constitutional causes* include all the factors likely to impair the general health and resistance of the individual *e.g* fatigue, under-nourishment, loss of sleep, worry etc. *Local causes* include a wide variety of conditions (*e.g* calculus, pregnancy foreign-bodies, hydronephrosis, congenital malformation, etc.) all of which have one feature in common, *viz* they give rise to stasis or obstruction in the upper urinary tract.

Symptoms These consist chiefly of pain and tenderness over the affected kidney increased frequency of micturition and the presence of pus in acid urine. Necessarily where pyelitis follows chronic cystitis, the acid reaction is neutralized if the urine in the bladder has become alkaline. The highly acid urine often causes scalding at micturition. The general condition of the patient is much upset, the temperature is high (particularly in children) and rigors are not unusual. The tongue is dry and the pulse rapid. The urine is acid, hazy (due to bacilluria) and has a fishy odour in the later stages there may be a heavy deposit of pus and mucus. At cystoscopy the

ureteric orifice of the affected side will be red and œdematous, while efflux of turbid urine may be observed.

Treatment The treatment of pyelitis is directed first to the disease itself and secondly to its predisposing causes.

Rest in bed with fluid diet is important the patient should be encouraged to drink freely of barley water etc. Attention must be paid to the bowels, alkalies (potassium citrate) and sedatives (tincture of hyoscyamus) should be administered in full doses six hourly Urinary antiseptics should not be reserved for the later stages or an acute attack may proceed to a chronic infection. Many cases pass into a condition of chronic pyelitis from which acute exacerbations are liable, so it is important to persevere with treatment at the first attack, the soluble sulphonamides, *e.g.* sulphamethizole being given.

The predisposing cause should be treated after the subsidence of the acute stage of pyelitis. Radiography is always important to exclude stone, which must be dealt with. Similarly urethral stricture and other predisposing causes must have appropriate treatment

Measures to improve the patient's general health and powers of resistance (*e.g.* prolonged rest, liberal nourishing diet, freedom from worry etc.) are of importance when the predisposing cause is a constitutional one.

Pyelonephritis. Inflammation of the pelvis of the kidney together with the renal parenchyma, is almost invariably suppurative in type and due either to extension upwards from the lower urinary organs, or to local lesions of the pelvis or kidney The kidney becomes swollen and purple, with cloudy swelling of the epithelium In the later stages bacteria invade the pyramids and travel upwards along the lymphatics or renal tubules, giving rise to abscesses, either scattered through the connective tissue of the organ or within its tubules, in either case seriously damaging its excretory function. In both instances it is possible for many of these minute foci of pus to run together and form a large collection, which in time may become recognizable from outside but more usually the patient dies of toxæmia or uræmia long before that stage is reached. When the affection ascends from the bladder it may start suddenly with acute symptoms and then probably results from some surgical operation or simply from catheterization in a patient whose bladder is in a highly septic condition The organisms find their way upwards along the ureters and infect the pelvis.

Clinical History In acute cases the symptoms usually start with a severe rigor associated with pain in the loins or back, headache, vomiting great thirst, and sometimes drowsiness or even coma They may have been preceded by signs of a pre-existing bladder infection, such as acute dysuria or strangury for a few days. The rigor may be repeated or the fever may remain high without exacerbations, but if uræmia is present or threatening, the temperature may be subnormal. The kidneys are felt to be enlarged and tender the urine is usually diminished in amount and indeed may be suppressed entirely if any passes, it is high-coloured and contains albumen and perhaps blood, generally with large quantities of pus. The prognosis of the worst cases, which supervene on old bladder trouble, is nearly hopeless, the patient being almost certain to die of uræmia, especially as both kidneys are generally affected. In less acute cases, occurring most often in young people, secondary to a bacillary cystitis, the symptoms often improve in a few days but the urine is swarming with bacilli and

recurrence of the trouble is usual Suppuration may sometimes supervene either in the renal pelvis, cortex or perinephric tissues

In the more chronic cases the *symptoms are those of pyrexia*, at first only slight but gradually increasing and taking on the hectic type The kidney is slightly enlarged and tender the urine contains pus epithelial cells from the pelvis or renal casts. As the condition progresses and tempera ture rises the patient wastes and is very sallow appetite and digestive functions flag slight delirium supervenes at night Unless treatment with sulphonamides and antibiotics is started death from uræmia is likely to follow *If however effective treatment is instituted recovery follows*, but the kidney may be permanently damaged and some degree of sclerosis follows

Treatment A sterile specimen is sent to the laboratory for culture and sensitivity to the various antibiotics is determined at the earliest possible moment *so that chemotherapy can be promptly instituted* In the chronic variety the cause must first be dealt with, but the surgeon must not forget that an acute attack may easily be lighted up by injudicious instrumentation or operations. Hence it is often desirable to drain and wash out the bladder first, as by a suprapubic cystotomy rather than at once to dilate or divide a stricture of the urethra or to remove an enlarged prostate or calculus. At the same time the patient is kept in bed and encouraged to drink plenty of bland fluids. If the urinary secretion is not re-established or if it is suppressed, or if suppuration unfortunately supervenes, incision of the kidney and drainage of the pelvis (nephrostomy) should not be too long delayed It is sometimes remarkable to observe how rapidly the symptoms improve after such a procedure, and how quickly the urinary secretion is re established.

Pyonephrosis. This term is applied to indicate the association of chronic pyelonephritis *with distension of the pelvis and ureter as a result of obstruction* of the passage of urine. It may be unilateral or bilateral open or closed. When unilateral, it is most commonly due to the presence of a calculus, or of tuberculous ureteritis if the affection is secondary to obstruction in the lower urinary passages, it is usually bilateral. The lining membrane of the pelvis is inflamed, thickened and perhaps ulcerated decomposing urine and pus collect in the dilated pelvis and calyces, and a soft friable, phosphatic calculus may develop *even in cases where the originating cause* is not of a calculous nature. Obstruction to the outlet may lead to such an accumulation of pus as to constitute an abscess of the kidney while perinephritis in varying degrees is always present, rendering the kidney fixed and adherent to neighbouring structures. If the obstruction is low the ureter will be dilated and often filled with pus (pyo-ureter)

Clinical Signs These are very similar to those of pyelonephritis but to them are added those of an *enlarged, fixed tender and painful kidney* and abundant pyuria, usually intermittent. The temperature is somewhat raised, especially at night, from the absorption of toxic products the patient *becomes emaciated the tongue is dry* the appetite diminished and nausea and vomiting are sometimes present. The urine is generally scanty in amount and if both kidneys are involved the excretion gradually diminishes, *leading to a fatal issue* from uræmia unless the patient dies *previously from* toxæmia or pyæmia. At cystoscopy a thick column of pus may be seen issuing from an open œdematous ureter like tooth-paste squeezed from a tube.

Treatment Where both kidneys are involved as a result of some urethr

or prostatic affection, no special treatment directed to the kidneys is feasible, except bilateral nephrostomy but if the condition is unilateral nephrostomy should be undertaken and any removable cause dealt with Appropriate chemotherapy is started. Later if the other kidney is healthy when the acute process has subsided, nephrectomy may have to be performed

Focal Suppurative Nephritis. When multiple suppurating lesions are found in the parenchyma of an otherwise normal kidney this term is used. Two distinct clinical types are recognized the acute and the subacute.

The *acute* form is of little surgical importance and occurs in the course of certain severe blood-steam infections, for the most part coccal in origin. Organisms carried to the glomeruli by the different vessels give rise to *multiple small cortical abscesses—the so-called "flea bitten" kidney* of pyæmia or septicæmia. The condition is always bilateral treatment is directed entirely to the blood-stream infection and chemotherapeutic substances have a *profound* effect. Local measures such as decapsulation, drainage, etc., are rarely called for

The *subacute* form differs from the preceding in that the lesion is nearly a circumscribed and unilateral one a difference explained by the supposition of a *single* bacterial embolus from a distant focus of suppuration. The primary is nearly always in the skin (furuncle carbuncle paronychia, etc.), but may sometimes arise from infections of the respiratory tract or bone (osteomyelitis). There is often a long latent period between the original superficial infection and the onset of renal symptoms The causative organism is nearly always found to be the *Staphylococcus aureus.* The lesion commences as a localized area of inflammation in the cortex in which multiple foci of suppuration rapidly make their appearance The resemblance to a carbuncle of the skin becomes a striking one, hence the term "carbuncle of the kidney The areas of softening tend to fuse ultimately forming one large abscess near the centre of the lesion. Pus may track in two directions firstly outwards to the perinephric space secondly *inwards to burst into the renal pelvis* The former is the more common and will give rise to a perinephric abscess the latter is associated with sudden marked pyrexia and is followed, in some cases, by free drainage and spontaneous resolution. Symptoms are insidious and the course subacute. Fever malaise anorexia, headaches and other constitutional disturbances are *generally* marked Pain and tenderness in the loin are followed by enlargement of the kidney as the lesion progresses. Urinary symptoms are absent. Diagnosis is made by local signs, leucocytosis, X-ray and the finding of *Staph. aureus* in centrifugalized urinary deposit. Intravenous pyelography may yield useful information and will show deformity or displacement of the renal pelvis when the carbuncle is large

Treatment Penicillin or other antibiotic, in full doses, will often effect a cure in the early case but a perirenal abscess requires drainage and nephrectomy may be necessary if the kidney is entirely disorganized.

Perinephritis. This is usually recognized only when suppurative in nature it may be primary following boils tonsillitis etc and is a blood-stream infection, or it may be secondary to neighbouring suppuration from kidney—most frequently a staphylococcal cortical infection—appendix, pleural cavity ribs spine etc. The abscess is usually behind the kidney but may be found in any relation to it.

Symptoms. In acute perinephritis signs of deep suppuration in the loin

are produced *vi* an indurated painful swelling, associated with fever and perhaps preceded by rigors. The body is held stiff and rigid with an inclination towards the affected side Fluctuation may sometimes be detected when pus has formed but the abscess is often so deeply placed that it is difficult to recognize at first it is likely to point at the side of the erector spinæ or may burrow forwards between the abdominal muscles, and find an exit on the anterior abdominal wall Occasionally it bursts into the peritoneal or pleural cavities or into the intestine If it comes to the surface, it is preceded by congestion and œdema of the skin. *Chronic perinephritis* gives rise to no characteristic symptoms until an abscess forms which is large enough to be felt If of the non suppurative type, as occurs sometimes with tuberculosis or chronic staphylococcal abscess much fibrous tissue may be laid down forming a hard fixed swelling and rendering operative intervention very difficult

Treatment In the suppurating variety the pus must be drained through an incision at the outer border of the erector spinæ the cavity is then carefully examined and the cause of the suppuration if possible, determined and treated according to the requisites of the case

Tuberculous Disease of the Kidney

Tuberculous disease of the kidney occurs in one of three forms

Miliary Tuberculosis. This form arises in the course of acute general tuberculosis, when miliary tubercles will be found studding both organs Treatment is by streptomycin isoniazid and PAS in large doses

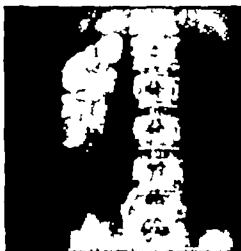


FIG. 49 7 CALCIFICATION OF THE KIDNEY AND URETER FOLLOWING A LONG-STANDING TUBERCULOUS INFECTION.

Pre-clinical Renal Tuberculosis. This is a term applied to the multiple bilateral microscopic tuberculous lesions which are found experimentally after intravenous injection of tubercule bacilli (Medlar) and are thought to precede all cases of destructive tuberculosis. This condition is quite symptomless but can often be demonstrated in patients with active extra renal tuberculous lesions, by the fact that the urine contains tubercule bacilli (so-called tuberculous bacilluria). The urine may also contain a trace of albumen but never any pus cells. Pre-clinical lesions may heal under

favourable conditions but in some cases a destructive process of one kidney may supervene, associated with pyuria and the appearance of symptoms.

Chronic Destructive Tuberculosis ("Surgical" Tuberculosis). This is generally unilateral in the early stages (80 per cent.), but is bilateral in 60 per cent. of cases at death it is more likely to be bilateral in children. The infection is by the blood-stream a tubercle is formed at the apex of a pyramid, which will proceed to caseation and ulceration from this area there will be seen streaks of infected lymphatics to the overlying capsule, which will become thickened and adherent at this part and fresh tubercles may form in the cortex from this lymphatic spread. Fibrosis at the apex of the calyx will lead to occlusion of that part of the kidney and to *tuberculous hydronephrosis* but if secreting tissue has been destroyed in that segment, *massive caseous tuberculosis* will result. Calcification of old lesions is very common. *Tuberculous perinephritis* from the infected capsule will cause adhesions and possibly an abscess in the perinephric fat



FIG. 49 8 TUBERCULOUS KIDNEY SHOWING THICKENING OF THE MUCOUS MEMBRANE OF THE PELVIS AND URETER. (*King's College Hospital Museum.*)

Simultaneously the infection will spread to the pelvis, ureter and bladder submucous tubercles occur and by their production of tuberculous granulation tissue may block the ureter with caseous débris or by stricture from the contraction of fibrous tissue. The ureter may ultimately be converted into a hard thickened cord, which by contraction drags upon its outlet in the bladder and may even partially rotate the bladder

Symptoms These are at first indefinite, and are more likely to be present when there is early spread of infection to the bladder The patient is usually a young adult, rather more frequently a male than a female He complains of increased frequency of micturition and sometimes unilateral pain in the loin, neither of which conditions is improved by rest, *remaining the same* by night as by day There may be a true polyuria in early stages owing to diuresis. The pain is generally of an aching character and more or less

constant although exacerbations may occur taking on the type of mild renal colic in consequence of the passage of fragments of disintegrated mucous membrane or of caseous material *Local pain may be entirely absent even when the lesion is extensive In some cases pain may be felt over* the non-affected side and is due to stretching of the capsule by a kidney undergoing compensatory hypertrophy The urine is acid and usually contains a certain proportion of pus *Myco tuberculosis* can usually be found after centrifugalizing a complete twenty-four hour specimen Hæmaturia varies in amount, it may be the first symptom to appear or may not occur at all the bleeding may come from the kidney or from a tuberculous ulcer in the bladder this *latter is capable of causing considerable hæmorrhage.* Loss of weight, night sweats and a nocturnal rise of temperature are present only in the later stages On examination the kidney may be slightly enlarged with some tenderness, but it must be remembered that one kidney may be destroyed with hypertrophy of the other when the enlarged kidney is in fact the healthy one. A thickened ureter is occasionally palpable on abdominal rectal or vaginal examination.

Diagnosis The age of the patient and his personal and family history may be of importance and he should be carefully examined for evidence of tuberculous disease elsewhere, especially in the genital organs particularly prostate and seminal vesicles Pus in acid urine in which pyogenic bacteria are not found is most suggestive of tuberculosis which will be established by *finding the acid-fast Koch's bacillus Radiography will determine* the presence or absence of a stone, but also of calcified caseous deposits. Cystoscopy may reveal the existence of tuberculous lesions in the bladder close to the ureteral orifice in the earlier stages or of a retracted ureter when the latter has become transformed into a solid cord. Intravenous pyelography *should be carried out in all suspected cases of renal tuberculosis.* The earliest pyelographic changes will be seen in the minor calyces which lose their normal cupped appearance and become dilated and fluffy In advanced cases the calyces become grossly dilated and irregular in outline. Exclusion of contrast medium will diminish *pari passu* with parenchymal destruction until finally the kidney becomes completely functionless and no shadow is seen on the affected side.

It is often necessary to catheterize each ureter to determine whether the infection is unilateral or bilateral in cases of doubt the urine from a suspected kidney may be injected into a guinea pig, which will show evidence of tuberculosis in some eight or ten weeks in positive cases or else cultured on special media.

If severe, tuberculous cystitis renders recognition of the ureteric *orifices* difficult these may be seen after intravenous injection of indigo-carmine and catheterized

Treatment The discovery of the anti-tuberculous drugs has had a considerable impact on the treatment of this disease. Previously it was agreed that nephrectomy while the disease was *still unilateral*, was the only form of treatment likely to effect a cure. Now the indications for surgery are becoming more clear and may be summed up by saying that they are to correct obstruction, promote drainage and excise closed caseous areas. Ideally no drug treatment should be begun until a positive culture or guinea pig inoculation has been obtained *and* at *least six weeks* treatment should be given before surgery is contemplated. Exceptions are where a superadded

pyogenic infection is causing toxic symptoms or a gross pyonephrosis exists.

Nephrectomy is required in advanced unilateral lesions. The ureter is removed down to the brim of the pelvis if it is not thickened, or as far as the bladder if it is involved. A solution of streptomycin is injected into the cavity and the wound closed without drainage. Partial nephrectomy is sometimes justifiable for a localized focus of small size which has remained resistant to chemotherapy

Following operation, anti-tuberculous drugs must be continued and the patient kept under observation until the disease is considered cured, often a matter of months or years. Owing to the frequency of genital involvement the prognosis is always worse in males than females. After nephrectomy the disease may be dormant in the prostate or seminal vesicles and become active after many years to infect the remaining kidney or other parts of the body

Renal Calculus

Ætiology All renal concretions are excreted in a crystalline form from the renal tubules, but under ordinary circumstances are sufficiently small to find their way into the pelvis of the kidney and thence along the ureter to the bladder If however they are obstructed in their onward course, either on account of their size or shape or some narrowing of the tubules, they may become lodged in the kidney substance or in one of the lower calyces, and by the gradual deposit of the same material increase in size until large enough to give rise to symptoms

Apart from obstruction there are many other ætiological factors such as climate diet, errors of metabolism, etc., although their exact significance is still imperfectly understood. Certain chronic renal infections due to urea-splitting bacteria (*Proteus* and the staphylococcus) often give rise to the formation of large phosphatic calculi. Cystin calculi are due to a congenital defect in the metabolism of nucleo-proteins the tendency is often a familial one Renal calculi are usually not of great bulk occasionally however the whole of the pelvis and some of the calyces may be occupied by a concretion, which takes the shape of the cavity in which it lies (stag horn calculus). When many calculi are present in the pelvis of a kidney they are usually faceted. Chemically they consist most commonly of oxalate of lime, though in some few cases they are composed of uric acid or urate of ammonium when associated with chronic renal infection, they are usually composed entirely of phosphates

Pathology The phenomena connected with renal calculi vary with their size shape number and position. If situated in the substance of the renal parenchyma, they give rise to little trouble being more or less encapsuled in a cavity lined by granulation tissue or surrounded by a dense fibrous capsule. Sometimes ulceration of the wall and suppurative perinephritis may follow the calculus may even find its way into the abscess cavity and be discharged spontaneously or removed through the loin a urinary fistula perhaps resulting. The calculus may be gripped by the neck of one of the calyces and thus immobilized the calyx involved will then become dilated (hydrocalicosis) and the kidney substance thinned over it. At times the whole pelvis is filled by a large branching calculus extending into a number of calyces (Fig. 49 9) there is then little mobility but infection

follows, and the kidney substance is seriously damaged When lying loosely within the pelvis of the kidney a calculus may cause obstruction to the flow of urine partly by thickening of the mucous membrane and partly by the stone engaging the orifice of the ureter producing dilatation of the pelvis of the kidney the phenomena of hydro- or pyo-nephrosis. If the calculus passes down the ureter it gives rise to the symptoms of *renal colic* When small and smooth it usually reaches the bladder without much difficulty



FIG. 49 9 A LARGE BRANCHING CALCULUS IN THE RIGHT KIDNEY

and is then voided with the urine or remains as a vesical calculus. Occasionally owing to its size or irregular shape, it becomes impacted in the ureter giving rise to acute obstruction and the cessation of the urinary secretion on that side, followed in time by disorganization. If the kidney thus affected is the only one available for excretory purposes, or if both ureters are similarly obstructed the patient, if unrelieved, dies in a few days from suppression of urine (*calculous anuria*) In other cases the stone ulcerates through the wall of the ureter leading to a retroperitoneal urinary abscess, or possibly to suppurative peritonitis. If the ureter is only partially ob-

structed by the calculus, the changes which take place in the kidney are more gradual and result in hydro- or pyo-nephrosis.

Symptoms. The typical symptoms of renal calculus are as follows The patient complains of pain in the loin more or less persistent, and often paroxysmal in nature, which is, however usually increased on exercise or jolting it is frequently referred to distant regions, but most commonly follows the course of the genito-femoral nerve giving rise to pain in front of the thigh, accompanied by retraction of that testicle, in the female it is experienced in the labium majus, sometimes it also extends down the back of the thigh It is almost invariably associated with hæmaturia, and often with pyuria. Frequency of micturition is a prominent symptom and if the pelvis is enlarged the kidney may be tender and distinctly palpable If the calculus is lodged in the renal parenchyma, the urinary secretion may be little influenced, although the characteristic pain is well marked. The patient also finds that at night he can only gain relief by lying on the affected side, and on manual examination the kidney though somewhat tender is not much enlarged When the calculus lies in the pelvis or one of the calyces, typical symptoms are produced. On the other hand it is an undoubted fact that stones even of large size may exist for years in the kidney without giving rise to any symptoms whatever

Renal colic is the pain arising from the passage (or attempted passage) of a calculus down the ureter There is excruciating pain of a paroxysmal nature, which comes on suddenly and is referred both to the loin and along the course of the genito-femoral nerve. It is always associated with vomiting and severe shock, the patient often lying on the floor writhing in agony with cold perspiration standing in beads on his forehead. The temperature is subnormal and the pulse weak and rapid. Strangury is usually present, the patient suffering from frequent paroxysmal efforts to pass water, but only succeeding in voiding a small amount, and that generally blood-stained. After lasting for a variable period, the pain suddenly ceases, as a result of the passage of the calculus into the bladder or of its slipping back into the pelvis of the kidney

Impaction in the ureter may occur at any level, but is more common below the brim of the pelvis. Generally only one stone is present, but occasionally more the size is rarely greater than a coffee bean and the shape is usually somewhat elongated, like a date-stone. Impaction is more likely to occur when the surface of the stone is rough. In thin persons it has been detected on palpation through the abdominal wall, when low down it has been felt on rectal or vaginal examination

Should the ureter of a solitary kidney be blocked by a stone, grave symptoms of *calculous anuria* or suppression, will arise. The condition is ushered in by pain in the loin of the usual character which often passes away in two or three days. The anuria is rarely complete at first, a few ounces of pale limpid urine being passed at intervals while occasionally distinct polyuria is present. Sooner or later definite uræmic phenomena supervene the most usual period is seven or eight days after the onset, but incomplete obstruction or a pre-existing condition of hydronephrosis may delay matters. Calculous anuria should always be regarded as a surgical emergency and measures to relieve the obstructed kidney should be promptly undertaken. The treatment of anuria by the artificial kidney is discussed in Chapter 5.

Diagnosis. The diagnosis of a stone is often a matter of uncertainty in the absence of a history of the passage of gravel or of the occurrence of renal colic. The final determination of the presence or not of a renal or ureteral calculus can only be made with certainty by radiography Reference has already been made to some of the conditions which must be observed if a reliable result is to be obtained It is a good rule to follow that a secondary confirmatory examination should be made after an interval of two or three days in all cases where the diagnosis has not been established beyond all shadow of doubt If a small stone has been located in the kidney and operation has for some reason or other been deferred it is always advisable that a confirmatory radiograph be taken immediately before the operation Cases have been known where a stone had, during an interval shifted its position from the kidney to within an inch or two of the lower end of the ureter without any symptom which could suggest the change of position

Treatment Attacks of renal colic are treated by the use of heat warm drinks, and hypodermic injections of morphine and atropine.

Expectant treatment is justifiable in the case of small renal or ureteric calculi provided they are not causing infection or dilatation of the ureter and/or pelvis above. It must be remembered that 90 per cent. of calculi which are less than 1 cm. in diameter will be passed spontaneously Forced fluids, exercises and posture (especially when a stone is lodged in the lowest calyx of the kidney) all play an important part in aiding the passage of calculi.

When a stone is impacted at the lower end of a ureter certain conservative measures such as dilatation or incision of the ureteric orifice dilatation of the ureter with bougies and other cystoscopic manœuvres may avoid the necessity of an open operation in some cases.

Nephrolithotomy This is always undertaken through the loin. When exposed, the kidney is carefully freed and drawn up into the wound in the majority of patients it can be brought out on the loin and this is certainly a desirable manœuvre. The whole organ is then carefully palpated as also the pelvis and upper part of the ureter so as to locate if possible the stone. Should it be felt distinctly within the kidney substance or should an area of thinned cortex exist, an incision is made over it through the renal parenchyma. Should the stone not be palpable, it may be possible to detect it by needling the organ and failing that, an incision is made through the convex border of the kidney substance a little posterior to the mesial plane of the organ and at the junction of its inferior and middle thirds ("bloodless line" of Brodel). One of the lower calyces is opened by this means and the interior of the pelvis is carefully and fully explored by finger and probe It is unwise to incise the kidney to any extent, especially in searching for a small calculus the hæmorrhage is always severe, and although checked by sutures, these may be dissolved in six or eight days and secondary hæmorrhage may arise. When the pelvis is much distended and the patient has previously passed a good deal of pus, careful precautions must be taken to protect the surrounding tissues from infection. Bleeding is usually controlled without difficulty by slings of ribbon catgut passed around the kidney and tied over plugs of fat or muscle (Lowsley's technique) Deep mattress sutures should be avoided because of the danger of secondary hæmorrhage following pressure necrosis. It is wise to insert a drainage-tube

down to the sutured wound in the kidney after it has been replaced. The abdominal parietes may then be closed in the usual way

The incision was formerly made through the cortex in preference to opening directly into the pelvis but the objection often stated that a pelvic incision heals with difficulty and is liable to leave a fistula is not true and most surgeons now deliberately open the pelvis (*pyelotomy*) in order to extract stones if it is more convenient to get at them in this way Avoidance of damage to the renal parenchyma and a lessened risk of secondary hæmorrhage make pyelolithotomy the operation of choice whenever possible. An incision large enough to introduce the gloved little finger may be made, and by this means the whole kidney can be explored bimanually Accurate suturing with catgut is generally successful in securing immediate healing. Stones are removed by dressing forceps or scoop and care must be exercised to prevent any from falling back into the ureter Large branched calculi are often held very tightly and require an extensive incision and careful peeling from the kidney substance The pelvic cavity need not be irrigated under ordinary circumstances, but when dilated and suppurating it is well to do so with a hot solution of 1 in 10,000 silver nitrate Before closing the wound in the kidney or pelvis the ureter should be thoroughly examined it is sometimes possible to introduce a ureteral bougie through the open wound, but this is by no means easy in the renal operation, it is then often wiser to do this *via* the opened renal pelvis.

Ureterolithotomy To expose the ureter the incision is prolonged downwards and forwards in a direction parallel with the inguinal ligament towards the inguinal canal. The peritoneum and its contents are pushed bodily inwards and the ureter attached to the posterior peritoneal wall, can be followed down to within a few inches of the bladder For a stone impacted near the lower end of the ureter ureterolithotomy is performed with the patient in the Trendelenburg position. The operation may be transperitoneal or retroperitoneal.

(1) The transperitoneal operation is conducted through an incision in the middle line The stone is located and if possible, coaxed by the finger out of the depths of the pelvis to a more accessible position It is then cut down on through the peritoneum and the stone removed. The incision is closed by Lembert sutures and a retroperitoneal drain inserted.

(2) The retroperitoneal route is more often used the incision being usually mid line but without opening the peritoneum, which is gradually peeled off from the side of the pelvis on which the ureter is to be examined. An incision similar to that for tying the common iliac artery may also be used The peritoneum and its contents are displaced inwards, and the ureter is easily found running down on its posterior aspect. The stone is, if possible, displaced up from the pelvis and removed Cases seem to do equally well whether the ureter is sutured or not when the stone is small All operations involving incisions in the renal pelvis or the ureter must include drainage of the peri-pelvic or peri-ureteric regions for four to seven days.

Nephrectomy This may be required when the kidney is totally disorganized. Partial nephrectomy is sometimes indicated when a dilated calyx (usually the lower) is filled with calculi and the remainder of the kidney is healthy

Attempts to dissolve small calculi by means of solutions injected along

a ureteric catheter or nephrotomy tube have been made with varying degrees of success. Solution "G" which is a solution of buffered citric acid, acts as a feeble solvent of phosphatic calculi and is also used for washing out concretions in cases of alkaline encrusted cystitis

Cysts of the Kidney

Several cystic conditions affecting the kidney occur

Polycystic Disease There are two common clinical forms firstly the so-called "congenital" type, observed in young infants and secondly the

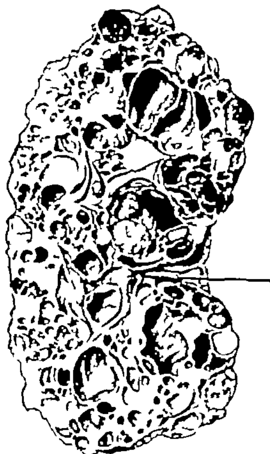


FIG. 49 10 CONGENITAL CYSTIC DISEASE OF THE KIDNEY
(*King's College Hospital Museum.*)
A probe is shown in the ureter

adult or "acquired" type where symptoms make their appearance about middle age. This is almost invariably bilateral. The kidney is enlarged and occupied by cysts, varying in size they are lined with epithelium which is generally flattened, and filled with a limpid fluid containing urea, and perhaps cholesterin. The cysts are very numerous, and project from the surface of the kidney as nodular elastic outgrowths. Similar cystic changes may be observed in other organs such as the liver and pancreas.

The pelvis remains unaffected until the later stages of the disease (Fig. 49 10) Generally the whole kidney is involved, and may attain enormous dimensions, constituting large swellings, which can be easily felt,

and with a distinctly nodulated surface occasionally the disease is limited to one portion of the organ. Diagnosis depends entirely on pyelography the appearances of which are characteristic. Confusion with hypernephroma will rarely occur if it is remembered that polycystic disease is almost invariably bilateral. The origin of this condition is uncertain, and there are many theories, the most popular being that retentive cysts are formed as a result of failure of union between the secretory (metanephric) elements and the collecting (Wolffian) elements of the renal tubules. In the early stages no symptoms are produced, except perhaps a sense of dragging weight in the loins from the size of the tumours but later on the secretion of urine is interfered with to such an extent as to produce renal incompetence and finally uræmia. Hæmaturia is sometimes the cause of drawing attention to the condition The terminal symptoms closely resemble those of chronic glomerular nephritis and secondary cardiovascular changes make their appearances in the later stages of the disease. The tendency of this affection to involve both kidneys makes the prognosis poor Puncture of the cysts using diathermy Rovsing's operation relieves pressure on the renal substance and produces improvement for a varying period. The kidney least affected should always be treated first.

Hydatid Disease. This affects the kidney as it may involve any other organ in the body It starts either beneath the capsule or in the glandular substance. In the former case it is likely to form a rounded projection which may be detected on palpation of the loin in the latter it expands, or even destroys the whole of the glandular tissue and may burst into the renal pelvis, the cysts being passed along the ureter accompanied by colic. Suppuration may complicate matters, but unless the cysts have ruptured into the renal pelvis, diagnosis is scarcely feasible apart from an exploratory incision

Treatment This consists in cutting down on the kidney and enucleating the mass, if possible Failing this, drainage may be undertaken, but when the cyst is entirely intrarenal nephrectomy is necessary

Serous Cysts. These are occasionally met with, arising possibly as a result of obstruction to some of the ducts or due to lymphatic obstruction. *Rounded swellings, simple or multiple, are produced* growing outwards from the cortex and containing a thin fluid, with a small amount of albumen and also salts in solution. They give rise to no symptoms except from their size, and rarely require treatment other than simple aspiration or drainage If discovered at operation and of considerable size, they should be incised, and either dissected out, or the outer wall cut away and the inner left continuous with the renal capsule

Traumatic Cysts. Such cysts may follow the incomplete absorption of a perirenal hæmatomata. They may sometimes communicate with the renal pelvis (traumatic pseudo-hydronephrosis)

Not infrequently a number of small cysts develop in connection with chronic granular nephritis they are of no clinical importance

Dermoid Cysts. These occur very rarely

Neoplasms of the Kidney

Tumours of the kidney may be innocent or malignant but the border line is very indefinite and as with tumours elsewhere in the renal tract it is best to regard even the simplest papilliferous tumour with suspicion.

Epithelial Tumours of the Renal Pelvis. These are comparatively rare. They may be simple (*papilloma*) or malignant (*carcinoma*) and resemble bladder tumours in their behaviour They are often associated with similar tumours in the ureter or bladder Hæmaturia is the commonest symptom but pain in the loin may be caused by obstruction to the renal pelvis by infiltration of the renal pedicle by extension of growth from the kidney or by metastasis in the spine A diagnosis can usually be readily made by pyelography which will show a filling defect caused by the tumour

The kidney and entire ureter should be removed at one operation if possible (nephro-ureterectomy) Associated tumours in the bladder are dealt with by cystoscopic diathermy or, if infiltrating, by excision or radiotherapy

Angioma of the Renal Pelvis. This is the rarest of the innocent growths of the renal pelvis and gives rise to painless hæmaturia Generally nephrectomy is required, but a few cases have been treated by local excision

"Essential" Renal Hæmaturia (*Renal Purpura*) Severe hæmaturia from one kidney may sometimes take place in young adults without gross macroscopic changes in the organ and in some cases the hæmorrhage may threaten life and even justify nephrectomy Careful pathological examination of these organs will sometimes reveal the presence of a minute angioma or a group of dilated vessels (so-called *renal hamartoma*).

Adenoma of the Kidney This may arise from the renal tubules. Small adenomata are fairly common, especially in kidneys affected by chronic glomerular nephritis. They rarely attain a large enough size to cause symptoms, but when they do they may closely simulate hypernephroma.

Wilm's Tumour (*Nephroblastoma* or *Renal Sarcoma*) This is generally regarded as a congenital embryoma but may be acquired within the first few years of life. It is encapsuled, the kidney substance being spread over it and consists of round or spindle cells, the latter often showing a cross-striation, resembling that of muscular fibres. It grows to a great size, and may affect both kidneys, with little pain or hæmaturia. Death results from general dissemination or from exhaustion or may follow the detachment of a sarcomatous embolus, which travels upwards and blocks the pulmonary vessels.

Treatment Nephrectomy has given most unsatisfactory results, the operative mortality having been high and recurrence within a short period almost invariable. The operation itself is not particularly difficult, but a large incision is required, and care must be taken to avoid displaced structures such as the inferior vena cava. A course of deep X-ray therapy before operation will diminish the size of the tumour (and possibly have an inhibitory effect) and is adopted as a routine measure by some surgeons. Because of their rapidity of growth such tumours are ideally treated as surgical emergencies with radiotherapy given post-operatively

Renal Sarcoma of Adults. This occurs between the thirtieth and fiftieth years of life and is of the spindle-celled variety often originating from the capsule Only one kidney is generally involved, giving rise to a rapidly growing swelling, associated with hæmaturia and perhaps pain. Secondary deposits form in the viscera extension through and beyond the capsule is not uncommon. The results of nephrectomy have not been very encouraging.

Primary Carcinoma. This is an uncommon form of tumour in the kidney It presents the same clinical features as a sarcoma and can only be recognized

on microscopic examination. The cells are small and deeply staining and arranged in an alveolar or papillary pattern One rare symptom however requires special mention, since it is extremely suggestive of the presence of cancer *viz* the development of a varicocele. It is due to the pressure of enlarged and cancerous lymphatic nodes upon the root of the spermatic vein and hence whenever an elderly person develops a varicocele a careful examination of the kidney on the affected side should always be instituted.

Hypernephroma (*Grawitz Tumour*). The commonest renal neoplasm, this variety accounts for between 75 and 80 per cent. of all kidney tumours. They were formerly looked on as growing from accessory and misplaced adrenals (adrenal rests), and develop primarily in the cortex as localized growths gradually increasing in size and encroaching on the pelvis. This



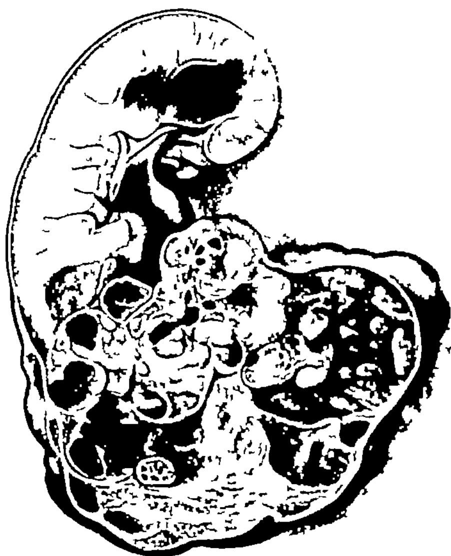
A B

FIG. 49 II HYPERNEPHROMA OF THE LEFT KIDNEY

A. Retrograde pyelogram showing "splaying" of upper calyx. B. The kidney after removal. The growth occupies the upper third of the organ.

theory has been abandoned in recent years and it is now customary to regard these tumours as true carcinomata of the renal tubules. They are of firm consistence but show areas of necrosis and softening, and deep red patches due to hæmorrhage the section is more or less mottled, and some bright yellow areas are very evident. On microscopic examination their appearance closely resembles the zona fasciculata of the adrenal bodies. They are malignant in type being disseminated by the venous route and secondary growths are found in the vena cava, lungs, liver or bones.

Hypernephromata usually occur in adults between fifty and seventy years of age and are of comparatively slow growth They give rise to hæmaturia but it is often late in appearance, and may be absent altogether Pain is often well marked and referred to the loin it is of two main types—a persistent aching pain, and a colicky pain, due to the passage of clots down the ureter Symptoms due to metastases may first cause the patient to seek advice, *e g* pain or swelling in a bone spontaneous fracture etc



[Royal College of Surgeons Museum

HYPERNEPHROMA OF THE KIDNEY

TO FACE PAGE 1254

Remittent fever is a constant accompaniment of certain hypernephromata. Its causation is obscure but it ceases after removal of the primary tumour. It is said always to make the prognosis more serious. The renal enlargement is usually characteristic but outgrowths from diffusion beyond the capsule may render the swelling of irregular shape.

Treatment. This consists in removal if there is no evidence of secondary deposits in the lungs or elsewhere. The widest possible exposure of the kidney is made, usually by the removal of one or more ribs or even by a trans-pleural approach. The renal vein and the vena cava must be carefully examined as extra-renal extension of the tumour is usually by the venous route. Embolectomy from the vena cava has been reported on many occasions, in some with successful results.

Hypernephromata are unusual tumours in that when they metastasize they often produce only one or perhaps two secondary deposits. For this reason it is considered justifiable to excise the primary tumour even when metastasis is present if this is solitary. A second operation is then performed to excise the secondary which is frequently in the lungs or bones. There are a number of cases on record of long survival after such treatment.

Carcinoma of the Renal Pelvis. This has already been mentioned. In addition to the usual transitional cell type the rarer *squamous carcinoma* may follow long-standing irritation by infection or stone and is often preceded by leucoplakia.

Treatment. Nephrectomy should be performed but the prognosis is poor due to the fact that the thin wall of the renal pelvis offers an ineffective barrier to an infiltrating tumour and extrapelvic spread is usually found at operation.

THE BLADDER AND PROSTATE

THE BLADDER

Methods of Examining the Bladder When a patient presents himself complaining of increased frequency of micturition or other evidences suggestive of chronic disease of the bladder a systematic examination of the individual and his urinary passages must always be instituted. The history of the case, the character of the symptoms, and the condition of the urine, are carefully gone into An examination of the bladder should then be made (*a*) The patient is laid on a couch, and the lower part of the abdomen uncovered. The hypogastrium is examined by inspection, palpation, and percussion, so as to ascertain whether or not the bladder is distended, or if any abnormal resistance can be felt, either from the thickening of the wall or the presence of a tumour (*b*) The finger is inserted into the rectum, or in the female into the vagina so as to enable the condition of the posterior vesical wall to be investigated. Enlargement of the prostate or of the vesiculæ seminales can also be detected in this way Bimanual abdomino-rectal examination which is best carried out under full anæsthesia is often a reliable method of estimating size of objects in the pelvis and thus plays an important part in the assessment of bladder tumours. Care should always be taken to empty the bladder first. (*c*) A sound is then passed and the interior of the viscus explored by this means a calculus may be detected. (*d*) The patient may then be asked to void urine after which a rubber catheter may be introduced and the amount if any of residual urine estimated (*e*) Examination of the interior of the bladder is carried out by means of the *cystoscope* This, in its simplest form consists of a straight tube with a short end bent at an angle in which an electric lamp is placed, the wires leading to it being carried within the tube A small window covered with glass is situated close to the angle, and a prism is here inserted in such a manner that, when the surgeon looks through an eyepiece placed at the end of the instrument, he is able to see the portion of the vesical wall illuminated by the electric lamp Introduction of the instrument may be difficult and is facilitated by the instillation of a local analgesic (*e g* 2 per cent lignocaine) into the urethra In those cases where the bladder is very irritable a spinal or general anæsthetic is given. About 300 to 400 ml of boric acid lotion or clear water should be injected into the bladder so as to flatten out the rugæ and allow inspection of the interior of the viscus Slight modifications of the instrument permit of the passage of a solid bougie or small catheter which can be inserted into the ureteral orifice and up the ureter (*f*) *X-ray examination* of the bladder is of particular value in cases of vesical calculus. The tube is centred over the umbilicus and slightly angulated caudally with the plate under the buttocks In a good film a faint outline of the viscus may be seen, the base approximately corresponding

to the upper border of the symphysis pubis and superior ramus of the pubis as far as the middle of the obturator foramen, the dome of the bladder is very variable its level depending on the degree of distention of the organ Apart from calculi intravesical shadows are rare but are sometimes observed when calcification occurs in bladder growths or in cases of long-standing "encrusted" cystitis Extra vesical shadows due to phleboliths, ureteric calculi or prostatic calculi may often cause confusion. (g) By filling the bladder with a radio-opaque substance its contour can be readily demonstrated on a skiagram This is known as *cystography* a method often used in the demonstration of vesical diverticulæ (Fig. 50 4) It may be carried out either by the intravenous route or else by catheter injection (retrograde cystography) (*h*) Measurement of the intravesical pressure can be estimated by attaching a manometer to a urethral catheter and is known as *cystometry* Charts showing intravesical pressures when known quantities of fluid are introduced can be obtained (*cystometrograms*) (*i*) Lastly *exploration of the bladder* is justifiable in certain cases, *e.g* bleeding from the bladder severe enough to endanger life where the cause cannot be ascertained or else in cases where rupture of the bladder is thought to have occurred after trauma.



FIG. 50 1 ECTOPIA VESICÆ.

1 Exposed mucous membrane of posterior wall of bladder 2, glans penis drawn up to cover lower part of vesical mucosa and orifices of the ureters 3 scrotum 4 projection of pubic ramus.



FIG. 50 2 ECTOPIA VESICÆ.

Catheters are inserted into the ureters.

A distended bladder constitutes a rounded swelling, which projects above the symphysis pubis and may even reach to the umbilicus in some cases. The swelling may be visible to the naked eye and is dull on percussion the dullness rising directly above the symphysis it is quite immovable, and therein differs from many ovarian and uterine tumours. Bimanual examination per vaginam or per rectum should at once indicate its nature when at all doubtful, a catheter should be introduced.

Congenital Affections of the Bladder

Ectopia Vesicæ (Extroversion of the Bladder). This term is employed to denote total absence of the anterior wall of the bladder and of the lower portion of the abdominal parietes, as a result of which the mucous mem

brane of the posterior vesical wall is exposed and rendered somewhat prominent by the pressure from behind of the abdominal contents. This surface is usually not much more than an inch in diameter in an infant, is often irregular and covered with papillary processes. The orifices of the ureters are easily recognized below urine being occasionally emitted from them in forcible jets. The condition is necessarily one of the greatest discomfort, not only from the constant dribbling of urine causing excoriation and eczema of the thighs and surrounding parts, but also from pain and irritation due to friction of the clothes against the exposed mucous membrane. Metaplasia of the exposed mucous membrane and finally carcinoma, will develop in many untreated cases during adult life. The symphysis pubis is always absent and the horizontal ramus of the pubic arch terminates on either side in the inguinal region The innominate bones are usually rotated outwards, and the sacrum is convex anteriorly from side to side instead of being concave The patient s gait and powers of progression are often impaired. The penis is cleft and in a condition of complete epispadias, is drawn upwards and backwards over the trigone so that it requires pulling down to expose the ureteral orifices The testes are often found in the inguinal canal or if in the scrotum are accompanied by congenital herniæ No umbilicus is present The condition is due to impaired development of the anterior wall of the allantois and the lower segment of the abdominal parietes At birth the lower portion of the umbilical cord is expanded over the raw surface constituting the anterior vesical wall When the cord separates the posterior vesical wall is necessarily exposed.

An *umbilical urinary fistula is sometimes met with as a result of imperfect* closure of the urachus. Occasionally in cases of malformation of the rectum the *primitive cloacal condition* may in part persist

Treatment The routine procedure now adopted for this distressing malformation is transplantation of the ureters, either simultaneously or one at a time, into the pelvic colon followed later on by excision of the exposed *bladder mucosa and skin-grafting or plastic repair of the defective abdominal* wall. The operation is usually undertaken after the age of two years. Plastic operations are sometimes attempted when the defect is not too great but urinary fistulæ or incontinence will develop from failure to reconstitute the bladder in the majority of cases

Injuries of the Bladder

Rupture may be produced in several ways (*a*) It may be due to direct violence applied to the lower part of the abdomen, especially when the viscus is distended. (*b*) It may complicate a fracture of the pelvis either as a direct result of the violence, or from penetration of a spicule of bone from the os pubis. (*c*) The bladder may be opened by a penetrating wound. (*d*) Apart from traumatic lesions, *rupture may occur from simple over* distension especially if destructive ulceration of its walls is present or it may be caused by intravesical surgical manipulations of various kinds such as excessive diathermy to bladder-growths perurethral resection of the prostate or simply by the passage of urethral instruments. (*e*) Accidental injury at operation, especially during the removal of large pelvic tumours.

Rupture of the bladder is *divided into two main classes according to* whether or not the peritoneal cavity is opened. The peritoneum covers the upper and back part of the viscus, being reflected anteriorly along the

urachus, laterally along the obliterated hypogastric arteries, and posteriorly on to the rectum

Intraperitoneal Rupture. This involves the posterior and superior portions of the viscus and is the variety most frequently met with The symptoms produced are shock associated with hypogastric pain of a burning nature Shock is very variable however and in some cases is absent altogether The patient experiences a constant desire to micturate, but, as a rule, nothing is passed except perhaps a little blood Peritonitis soon follows, running a rapidly fatal course if efficient treatment is not adopted.

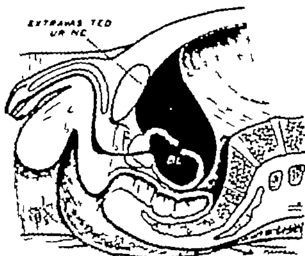


Fig. 50 3 Extraperitoneal Rupture of the Bladder

On passing a catheter the bladder is usually found empty or possibly a little blood-stained urine may be withdrawn if however the instrument happens to be insinuated through the rupture into the peritoneal cavity a considerable quantity of blood-stained urine can be drawn off and the point of the catheter may be felt under the anterior abdominal wall. A useful diagnostic sign consists in injecting a measured amount of saline or water into the bladder and noting how much of it returns when a rupture exists, some considerable discrepancy will probably be noted between the two quantities this test cannot, however always be relied on.

Cystoscopy is a valuable diagnostic measure in doubtful cases, but sterile water only must be used for distending the bladder and antiseptic solutions avoided because of the danger of absorption from the peritoneum.

Treatment The treatment of these cases consists in immediate laparotomy the fluid within the peritoneal sac is aspirated or mopped up by swabs, and the wound in the bladder clearly demonstrated preferably with the patient in the Trendelenburg position, which must not, however be adopted until the urine and inflammatory effusion have been removed. The rent is carefully closed by means of a row of Lembert sutures, which should always extend a little beyond each extremity of the wound and not involve the mucous membrane. The bladder is drained either by suprapubic cystostomy or by urethral catheter and, if peritonitis has developed, the pouch of Douglas is also drained.

Extraperitoneal Rupture. This involves the anterior wall or base of the bladder The urine finds its way into the pelvic cellular tissue and gives

rise to an insidious and dangerous form of suppurative pelvic cellulitis. Abscesses generally point either above the pelvic brim or in the perineum. The treatment consists in careful suture of the rent if possible and free incisions into the area of extravasation. A large suprapubic tube should be introduced into the bladder through which the urine can escape freely for a time. As soon as the tissues are sealed off by the development of granulations, the tube may be withdrawn. The prognosis largely depends on the condition of the urine, whether sterile or infected and on the length of time it is allowed to remain in contact with the tissues

Foreign Bodies. An astonishing variety of foreign bodies have been recorded in the bladder after introduction *per urethram* They give rise to symptoms of chronic cystitis, and usually become encrusted with phosphatic deposit. They should be removed as early as possible with a lithotrite or cystoscopic forceps but if of large size or thickly covered with phosphates, must be removed suprapubically

Cystitis

Cystitis is in most cases due to infection of the bladder by pyogenic bacteria (staphylococci streptococci, coliform bacilli), but sometimes the infection is a specific one and due to the tubercle bacillus. In some cases, however the urine will be found to be persistently sterile and to this group the term "abacterial" pyuria has been applied The reaction of the mucous membrane of the bladder to different types of infection will vary greatly so we find that qualifying terms such as "bullous," "ulcerative," "hæmorrhagic," etc., are often used in descriptions of the cystoscopic appearances of cases of cystitis

The *routes of invasion* of the bladder are diverse (*a*) Bacteria may reach the viscus from above either owing to a suppurative lesion of the kidney or its pelvis, or escaping into the urine from the blood. (*b*) They may travel up the urethra. This is a matter of no difficulty in the short and comparatively large urethra of a woman and hence cystitis is frequently associated with vulvitis or is seen after labour In girls a pure bacillary cystitis with acid urine is not uncommon, and is probably secondary to a vulvo-vaginitis, which arises from contamination of the vulva with the fæces where cleanliness is neglected. In the male sex, infection from the urethra is unusual unless urethritis has previously existed or instruments have been passed Even if they are carefully sterilized mucus is liable to form and cling about the urethral wall, and along this bacteria can find their way especially when a catheter has been tied in for continuous drainage. Naturally the introduction of an unsterilized instrument may suffice to cause cystitis. (*c*) Bacteria can invade the bladder from surrounding organs, being transmitted by lymphatic dissemination. Thus an injury of the rectum may easily lead to cystitis.

The mere presence of bacteria in the bladder is, however not sufficient as a rule to determine an attack of cystitis. Large quantities of pus are frequently discharged from the kidney through the bladder even for lengthy periods and yet no inflammatory reaction follows. Some predisposing factor must be added in order to excite their activity among the most favourable are the following

(*a*) Constitutional causes *i.e* lowered state of resistance to bacterial infection due to fatigue, under-nourishment, etc. (*b*) Injury as by the

presence of a foreign body a calculus or rough handling during an operation may open up a breach for bacteria to enter (*c*) One of the most important causes is retention of urine from whatever cause it is due *e g* enlarged prostate, stricture etc The bacteria tend to decompose the urine by splitting the urea molecule rendering it offensive and ammoniacal the toxins thereby produced affect the vesical mucosa (*d*) The presence of irritants in the urine may determine cystitis, as also pyelitis, *e g* after absorption of cantharides. (*e*) Loss of nervous control is a most important predisposing factor and comes prominently into play in spinal injuries. The greatest difficulty is experienced in protecting such patients, even effective purification of penis hands and catheter and the application of a sterilized dressing to the organ, after a catheter has been used may not suffice to prevent infection entering from without.

To recapitulate, cystitis will rarely if ever affect a completely normal bladder in a healthy individual it must therefore be regarded always as a symptom rather than a disease.

Pathological Anatomy In acute cases the mucous membrane of the bladder becomes congested and thickened the epithelium is shed mucus is excreted and is soon transformed into muco-pus, which may be extremely viscid and develops in large quantities. Ulceration of the bladder wall *may follow or even sloughing in the worst cases the whole of the mucous* lining may necrose, and be cast off as a slough. Sometimes a membranous form of inflammation occurs, the patient frequently passing flakes of some size, which on examination are found to be chiefly composed of fibrin.

In chronic cases the mucous membrane is thickened and congested the superficial veins dilated and even varicose while ulceration is not uncommon. The continued repetition of the act of micturition leads to hypertrophy of the bladder wall, which becomes thickened and fasciculated this effect is, of course, most marked when the cystitis is associated with obstruction to the outflow of urine. The mucous membrane may protrude outwards between the muscular fasciculi giving rise to pouch-like saccules in which phosphatic concretions are sometimes formed, while the retained urine undergoes decomposition. Ulceration and perforation occasionally follows, originating peritonitis or pelvic cellulitis from extravasation of urine. The contracted state of the bladder and the overgrowth of its muscular substance lead to compression of the openings of the ureters, hydronephrosis being thus induced Renal infections may occur as a result of a reflux of infected urine up the ureters.

Acute Cystitis. *Symptoms* These consist in pain referred to the perineum and hypogastrium, together with tenderness on pressure over the symphysis pubis. This is accompanied by extreme irritability of the bladder frequent efforts of a painful and spasmodic nature being made to pass water (strangury) little urine is voided at a time, for as soon as any amount has collected it is ejected forcibly It generally contains blood pus and bacteria. Fever is rare in uncomplicated cystitis and when observed is always due to associated infections in the kidneys or prostate gland. Tenesmus may be induced as a result of the proximity of the rectum to the inflamed bladder The usual termination of the case is in resolution, but sometimes chronic irritability may persist. In rare instances the inflammation is of such a virulent nature as to cause death. The urine in these cases is often exceedingly foul and the fatal issue is due to exhaustion, peritonitis,

suppurative pyonephrosis, or acute toxæmia. In some patients, however when the inflammation is concentrated at the neck of the bladder retention, distension and atony may ensue.

Treatment The patient should be kept in a warm atmosphere, preferably in bed with fomentations applied to the lower part of the abdomen hot baths twice daily maintained for some time, are very comforting. The diet should be restricted to fluid, and the patient encouraged to partake freely of barley water and other bland liquids. Alkalies and hyoscyamus may be administered and morphia and belladonna are useful to allay the pain and irritability As a rule, no instrument should be passed during the acute stage, unless retention is present The organism responsible should be isolated by the bacteriologist and its sensitivities to antibiotics determined. The wide-spectrum antibiotics are of most value tetracycline chloramphenicol and nitrofurantoin being among the most useful.

Chronic Cystitis. This is much more common than the acute variety and is usually associated with some irritation of the walls of the viscus, as from calculi tumours foreign bodies, tuberculous ulceration, or retention and decomposition of urine, especially if associated with obstruction to the outflow as by a stricture or enlarged prostate. It may also follow acute cystitis. A further cause is infection with the parasite *Bilharzia hæmatobia* This occurs most commonly in Egypt and symptoms are produced by deposition of the ova by the parasite, which lives in the portal system, in the veins at the base of the bladder Cystitis is the result of chronic irritation by the small foreign bodies and by a process of fibrosis the bladder and ureter may become seriously contracted. Patients reach temperate climes with chronic cystitis which gives a typical cystoscopic appearance of ground glass and particles of sand associated with an inflammatory reaction of varying intensity Ova are sometimes found in the urine or visible in the bladder wall. As a result of continued irritation, papillomatosis or carcinoma may arise.

Symptoms The symptoms are those of irritability of the bladder the patient constantly desiring to pass water and having to rise at night, perhaps several times, for this purpose. The urine becomes turbid and on standing, deposits a variable amount of mucus or muco-pus mixed with epithelial cells, crystals of triple phosphate and a granular sediment of phosphate of lime It is usually alkaline, perhaps foul-smelling and ammoniacal containing an abundance of micro-organisms. Pain on micturition is very variable and due rather to associated conditions (e.g ulceration or stone) than the actual severity of the infection. Apart from loss of sleep due to night frequency the patient s general health is not affected by cystitis provided the infection is confined to the bladder In other cases the inflammation may spread from the bladder along the ureters to the kidneys and the phenomena of septic pyelonephritis manifest themselves. Likewise the genital tract may be involved and give rise to symptoms and signs of prostatitis, vesiculitis or epididymo-orchitis.

The diagnosis of chronic cystitis is readily made from the characteristic symptoms of irritation of the bladder and the condition of the urine but considerable difficulty may be experienced in determining its cause In investigating a case, not only must the character of its onset be considered but also the general history of the patient a thorough examination of the lower urinary passages must always be instituted, and the urine examined

microscopically and bacteriologically The passage of a catheter or sound will generally detect any obstruction located in the urethra while the bladder is also examined by the cystoscope and other methods already described

Treatment The treatment of chronic cystitis is naturally directed towards its cause, if this can be discovered thus, calculi or foreign bodies should be removed and a stricture dilated Bladder lavage is of limited value In fact by the introduction of resistant organisms such as *Proteus* or *Ps aeruginosa* it will often do more harm than good In encrusted cystitis, acid solutions are sometimes used for bladder washouts with some benefit.

At the same time that this local treatment is being adopted, the patient's general habits of life must be regulated. The diet should be bland and unstimulating alcohol is better avoided but if essential for other reasons, well-diluted gin or whisky may be given. Coffee should be prohibited



FIG. 50 4 CYSTOGRAM SHOWING A DIVERTICULUM OF THE BLADDER.
This was found in a middle-aged male in association with a bladder-neck obstruction.

but tea and milk should be given freely together with barley water and alkaline Spa waters.

The operation of suprapubic cystostomy is very rarely needed for intractable cystitis it is simple with no special risks. A rubber tube with two or three openings at the distal end is placed in the bladder and the muscular wall stitched closely around a self-retaining catheter of the Winsbury White or Malécot type is especially suitable. The wound in the abdominal parietes is closed around the tube (not too tightly) by through-and through stitches and a dressing applied. A rubber tube sufficiently long to pass into a vessel containing water placed on a level lower than that of the bladder is united to the drainage-tube by a glass connection. As the urine is secreted it passes up the tube and soon overflows, establishing a syphon connection as soon as the air is expelled A useful alternative method is that of suction drainage the bladder drainage-tube is connected by a T-glass connection with a tube along which is kept running a stream of

water alternatively an electric suction apparatus *running at low pressure* is used.

Chemotherapy of Urinary Infection. The multitude of bacteriostatic and antibiotic substances, which are added to every year makes it imperative *that the organisms responsible for the cystitis be grown in the laboratory* and the sensitivities determined. The correct drug or combination of drugs can then be chosen The following include some of the more useful chemotherapeutic agents which may be employed.

Sulphonamides These are useful for *Esch coli infections* and being relatively non-toxic can be given over long periods. Sulphafurazole and sulphamethizole are two of the most useful as they are particularly soluble and appear in high concentration in the urine. The less soluble ones such *as sulphamerazine should never be used in children as they may cause* blockage of the renal tubules and anuria.

Penicillin Few urinary infections respond to this antibiotic but it is sometimes of value in combination with other drugs.

Streptomycin This must be given by injection and is effective against a wide range of organisms including the tubercle bacillus.

Chloramphenicol This appears in high concentration in the urine and is a particularly valuable drug. A rare complication of its use is aplastic anæmia.

Tetracycline and Oxytetracycline These are both wide-spectrum antibiotics of great value in resistant cases of urinary infection Treatment cannot be continued for long in some patients as alteration of the intestinal *flora leads to intractable diarrhœa.*

Nitrofurantoin This is a valuable urinary antiseptic with activity against a wide variety of organisms

Mandelic Acid. This is seldom used to-day It works by producing a *very acid urine in which many organisms cannot survive. The reaction of* the urine should be kept at pH 5 5 or lower and fluids should be restricted.

Tuberculous Cystitis. Tuberculous disease of the bladder is almost invariably secondary extending downward from the kidney or by extension from a tuberculous focus in the pelvis (*e.g* genitalia, peritoneum pelvic bones) It is much more common in men than in women and is most frequently seen in young adults It commences in the submucous tissue as a miliary tubercle which caseates and suppurates, breaking down and giving *rise to an ulcer with undermined edges these are rarely* of large size at first, are usually multiple and situated in or near the trigone

Symptoms These are those of chronic cystitis and hæmaturia the irritability of the viscus being very marked. The diagnosis is made by *demonstrating the tubercle bacillus in the urine*, and by the cystoscope.

Treatment The case is usually treated for some time as one of chronic cystitis before its nature as a tuberculous affection is discovered In most cases the infection in the bladder will subside spontaneously after chemotherapy has been instituted with streptomycin PAS and isoniazid. Where one kidney is grossly infected it may need removal or partial nephrectomy may suffice Similarly an infected epididymis may require excision Measures to improve the general health *i.e* sanatorium regime, are valuable ancillary treatment.

Simple Ulcer of the Bladder This is not an uncommon condition It is usually single and situated near the neck or trigone giving rise to great

irritability of the viscus and hæmaturia although the urine remains clear The diagnosis is made by the cystoscope. Phosphatic deposits sometimes form over the ulcerated surface and may suggest the existence of a stone Treatment consists in washing out the bladder with lactic acid (½ to 3 per cent), or diathermy is applied to the base of the ulcer through an operating cystoscope

Hunner s Ulcer This occurs in women usually at or near the menopause. The ulcer is shallow with an ill-defined edge and always situated at the apex of the bladder It is associated with ischæmic changes in the submucous and muscular layers of the fundus (interstitial cystitis) The symptoms are those of persistent chronic cystitis with pain and frequent slight attacks of hæmaturia as prominent features. Forced distension of the bladder under general anæsthesia will afford temporary relief of symptoms but more radical treatment consisting of excision of the affected area or transplantation of the ureters may be required in the more advanced cases.

Diverticula of the Bladder

Diverticula of the bladder of *congenital* origin are usually observed at the apex and are then probably due to imperfect closure of the allantoic sac. They may also be seen at the base just above the trigone, possibly in close relation to one of the ureteral orifices The latter may be due to some abnormality in the division of the primitive cloaca into bladder and bowel. These conditions are usually observed in young males and arise apart from any urinary obstruction

After middle age diverticula are nearly always *obstructive* in origin, the obstruction being one of long-standing, *e g* urethral stricture or con tracture of the bladder neck (Marion s disease) Diverticula are rarely observed in the female bladder They are associated with irregularities of micturition and are likely to be recognized on cystoscopic examinations for the same. The exact relation to ureters, etc., can be determined by radiography after an injection of sodium iodide aided by the passage subsequently of a ureteral catheter In most cases excision of the pouch can be undertaken, the obstruction being dealt with at the same time.

Multiple saccules which develop in consequence of hypertrophy of the muscular fasciculi of the bladder wall in cases where there is some obstruction to the vesical outlet are quite distinct from the solitary diverticulum. In diverticula the whole bladder wall is represented in the earlier stages, mucous membrane and muscular fibres being found in saccules only the mucous membrane is protruded as a hernial pouch between the muscular bundles. These gradually increase in size and are to be found most commonly on the upper part of the bladder Urine stagnates in them and undergoes decomposition the walls may become inflamed and even ulcerate or per forate a calculus may lodge therein and increasing by fresh deposits of the constituent salts may finally project into the bladder cavity being held in position by a narrow neck. Regression in the size of saccules may take place after removal of the obstruction but often the changes in the bladder wall are permanent, requiring suprapubic drainage when severe infection has developed

Neoplasms of the Bladder

Tumours of the bladder may arise primarily from the muscular bladder wall or more frequently from the transitional epithelium lining the viscus. Secondary involvement of the bladder by direct spread from neighbouring structures is not uncommon in the male from growths of the rectum pelvic colon and prostate and in the female from growths of the genital organs, especially the cervix uteri. Tumours derived from the bladder wall are rare and may be simple leiomyoma, fibroma or malignant sarcoma. The latter generally occur during infancy the tumours are usually multiple and tend to undergo myxomatous degeneration. Sarcoma of the bladder tends to disseminate rapidly and is usually fatal within a few months.

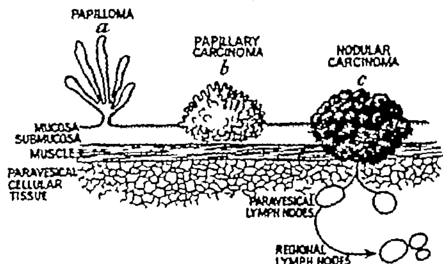


FIG. 50 5 DIAGRAM SHOWING VARIOUS TYPES OF EPITHELIAL TUMOUR OF THE BLADDER.

Epithelial tumours are very common in the bladder and the incidence is mainly confined to males between the ages of forty and seventy

Pathology These tumours vary considerably both in their structure and in their behaviour and the following clinical types can be distinguished.

Benign Papilloma This is a rounded friable tumour consisting of long delicate villous processes and a narrow pedicle attaching it to the bladder wall. Microscopically the epithelium covering the tumour is of the normal transitional type and the base membrane is everywhere intact (Fig. 50 6). This is essentially a simple tumour

Papillary Carcinoma This is a more compact tumour with relatively short fronds and a wider pedicle The cells of the tumour show abnormalities in their structure and their arrangement and actual invasion of the submucosa and muscularis may be observed in sections cut through the base.

Nodular Carcinoma. This is a rounded solid infiltrating tumour with a broad base. The surface which is quite smooth and free from villi is often ulcerated and phosphatic deposits may adhere to the raw surface.

Infiltrating Carcinoma As its name implies this tends rapidly to invade the bladder muscle and the lymphatics while at the same time the intravesical lesion remains relatively insignificant. In their more malignant forms transitional celled carcinoma lose their papillary arrangement and the cells revert to simpler rounded or spindle forms (" carcinoma simplex "). Squamous or glandular metaplasia is often observed in part of the tumour

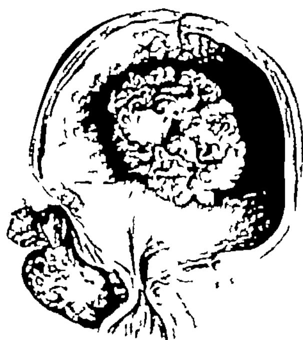


FIG. 50 6. PAPILLARY TUMOUR OF THE BLADDER. (*King's College Hospital Museum*)

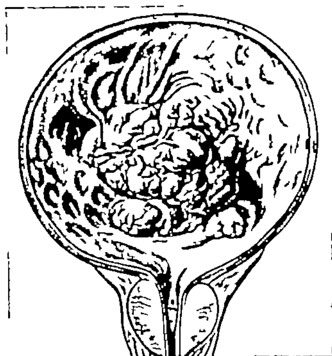


FIG 50 7 NODULAR CARCINOMA OF THE BLADDER. (*Royal College of Surgeons Museum.*)

Many epithelial tumours of the bladder tend to be multicentric and this accounts for the high incidence of so-called recurrences and the poor results after local removal In papillomatosis large areas of the mucosa are studded with papillary tumours in varying stages of development and the rapid

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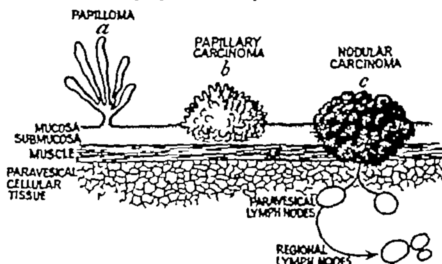


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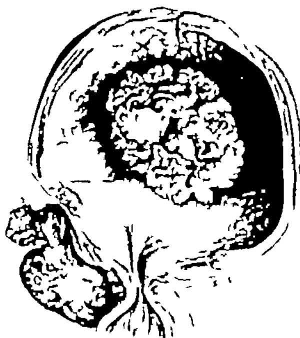


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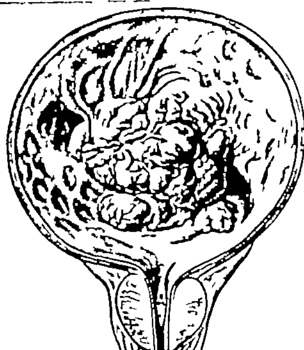


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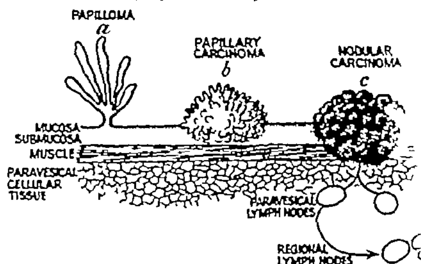


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suprapubic cystotomy This method is generally employed when the tumour is too large to be destroyed by perurethral diathermy or where the bladder requires to be opened in order to deal with some co-existing lesion (e g diverticulum or enlarged prostate). The main disadvantage, however is that it carries the risk of spilling of tumour cells and implantation in the abdominal wall or paravesical cellular tissues After opening and exploring the bladder a self retaining lighted retractor is introduced. If more room is required one of the rectus muscles may be cut across about 4 cm. above its insertion and the viscus can thus be freely exposed The larger growths are removed by dividing the mucous membrane, around them and cutting them away after ligaturing or cauterizing the base the incision in the mucous membrane should be closed by fine catgut if possible Smaller growths may be destroyed by diathermy *The finger of an assistant in the rectum can press* forward the posterior wall and give effective help Where the growths are very extensive this form of treatment may be supplemented by the local implantation of radon seeds, radium needles or radio-active tantalum wire.

Partial Cystectomy This consists in removal of the whole thickness of the vesical wall involved by the growth, and according to its location this may involve opening the peritoneal cavity or not An adequate amount of healthy bladder must also be removed. The bladder is exposed as described above and the peritoneum is detached up to and beyond the growth which is cut away the wall being made good by careful suturing with catgut. If the ureter is involved in this resection it should be divided through a healthy spot and reimplanted in the bladder Both partial and total cystectomy are employed for nodular or infiltrating neoplasms.

Total Cystectomy This is undertaken for extensive bladder growths which are incurable by less radical methods Improvements in the technique *of transplanting the ureters have considerably lowered the operative mor*tality in recent years and in carefully selected cases complete cystectomy is the treatment of choice

Radiotherapy Various methods have been greatly extended in recent years following the introduction of higher voltages and radio-isotopes. Anaplastic tumours are usually more radio-sensitive than more differentiated forms and are on the whole best treated by radiotherapeutic than by surgical methods but it must be remembered that surgery and radiotherapy are complementary and the choice of treatment is often made by direct consultation between surgeon and radiotherapist after a careful assessment of the tumour itself has been made High voltage (supervoltage) therapy interstitial irradiation with radium needles, radon seeds, radioactive gold seeds or tantalum wire, or intracavitary irradiation with radio-active solutions are the commonest methods of radiotherapy in use to-day While there is no operative mortality radiotherapy has certain drawbacks, not least of which is that of delayed radio-necrosis and fibrosis with severe bladder contracture, hæmaturia and ureteric obstruction as late complications in many cases after apparent cure of the primary tumour

Stone in the Bladder

Varieties. A vesical calculus may be formed of almost any of the urinary deposits met with, and each has its own special characteristics.

(1) The *uric acid* calculus is usually an oval, flattened body of consider-

formation of fresh lesions after their destruction by diathermy is a striking feature in many cases.

The favourite site for epithelial tumours to form is immediately behind the ureteric orifices. Except in anaplastic tumours, where early lymphatic invasion is often a prominent feature most bladder growths remain confined to the bladder wall for a long time and only involve the pelvic lymph nodes after they have spread through the entire thickness of the bladder muscle. Blood-borne metastases are rare.

Symptoms. The cardinal symptom is *hæmaturia* typically spontaneous, profuse and intermittent. When the tumour is non infiltrating there are usually long intervals between attacks of bleeding and micturition is quite painless. Pain, frequency and constant hæmaturia are characteristic of infiltrating tumours. Obstruction to the internal urinary meatus by an infiltrating or prolapsing tumour may give rise to difficulty or even retention of urine. Tumours of the fundus of the bladder often are symptomless and it is common to find a huge infiltrating suprapubic mass by the time the first attack of hæmaturia has occurred.

In the late stages, carcinoma of the bladder causes most distressing frequency and pain. The latter arising either from ulceration or infiltration of the bladder wall or else from involvement of pelvic nerves. In the terminal stages the patient becomes exhausted from pain hæmaturia, loss of sleep death is usually due to renal failure from ureteric obstruction by the pelvic tumour

Diagnosis. A bladder tumour can only be diagnosed with certainty by the cystoscope or by discovering fragments of its substance in the urine. Moreover as in other forms of malignant disease the chance of effecting a complete cure will depend on early diagnosis and for this reason the golden rule that cystoscopy should be undertaken in all cases of hæmaturia at the earliest possible moment cannot be over-emphasized

Wherever possible a biopsy of the tumour should be taken as this will not only establish the diagnosis with certainty but will in most cases, enable the pathologist to determine the grade of malignancy

Bimanual rectal examination preferably with the patient deeply anæsthetized, enables the surgeon to form an estimate of the size and depth of penetration of malignant tumours.

Lastly intravenous pyelography will usually reveal the state of the kidneys and ureters and will indicate whether the tumour has caused ureteric obstruction or whether there are other pathological changes in the upper urinary tract.

Treatment. When once a diagnosis has been established active operative treatment is essential. Two plans are available

Destruction by Diathermy For this a catheterizing cystoscope is employed, but instead of the catheter a flexible sound with a fine rounded metallic end which serves as an electrode is passed the remainder being carefully insulated The other terminal of the current is attached to a pad wetted with salt solution placed on the patient's thigh or abdomen The metallic terminal under the control of the eye is approached to one portion of the growth after another and as it touches and makes contact with it, the growth turns white and shrivels up This method of treatment is often tedious but excellent results are reported in the majority of non-infiltrating tumours.

Excision Papillary growths are sometimes treated by excision through a

suprapubic cystotomy This method is generally employed when the tumour is too large to be destroyed by perurethral diathermy or where the bladder requires to be opened in order to deal with some co-existing lesion (e g diverticulum or enlarged prostate) The main disadvantage however is that it carries the risk of spilling of tumour cells and implantation in the abdominal wall or paravesical cellular tissues After opening and exploring the bladder a self-retaining lighted retractor is introduced If more room is required one of the rectus muscles may be cut across about 4 cm above its insertion and the viscus can thus be freely exposed. The larger growths are removed by dividing the mucous membrane around them and cutting them away after ligaturing or cauterizing the base the incision in the mucous membrane should be closed by fine catgut if possible. Smaller growths may be destroyed by diathermy The finger of an assistant in the rectum can press forward the posterior wall and give effective help Where the growths are very extensive this form of treatment may be supplemented by the local implantation of radon seeds, radium needles or radio-active tantalum wire

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Varieties. A vesical calculus may be formed of almost any of the urinary deposits met with, and each has its own special characteristics.

(1) The *uric acid* calculus is usually an oval flattened body of consider-

able density with a smooth or slightly nodular surface and of a nut-brown colour On section it is distinctly laminated and it may be surrounded by a crust of phosphatic material.

(2) The *urate of ammonium* calculus is of very similar structure, but of a lighter colour and the lamination is less distinct.

(3) The *oxalate of lime* or mulberry calculus is a rough irregular body sometimes even nodular but not infrequently tuberculated, or even spiculated It is extremely hard and dense, homogeneous, crystalline and of a dark red-brown colour or sometimes black, owing to admixture with blood. It is rarely of great size, on account of the irritation caused by its presence and its slowness of growth.

(4) A pure *phosphatic* calculus is fairly common Furthermore any stone or foreign body is certain to become coated with a phosphatic deposit when chronic cystitis has resulted in alkaline decomposition of the urine. Occasionally concretions of a similar nature form spontaneously in saccules of the bladder these are white and chalky in appearance, friable in consistence, with no evidence or but little, of lamination, and on removal are exceedingly offensive they consist of a mixture of the triple ammonio-magnesic phosphate and phosphate of lime. Less commonly an excess of the triple phosphate is present if in the proportion of two parts of the latter to one of phosphate of lime, a laminated and somewhat denser calculus is produced, which is sometimes termed a fusible calculus, owing to the fact that it fuses to a bead under the blowpipe flame. Occasionally a phosphate of lime calculus occurs in the upper urinary passages, *e g* the pelvis of the kidney and has a crystalline appearance on drying.

(5) *Cystine* forms the base of a rare calculus which is of a yellowish-green colour and waxy in appearance It occurs as a familial inborn error of metabolism and presents in childhood or youth

(6) *Xanthine* or xanthic oxide occurs very exceptionally as a calculus of a reddish colour

An encysted calculus is one which develops in a saccule of the bladder It may consist of any of the above substances and is due to a small stone finding its way into a saccule and being arrested there. It grows by gradual accretion of new calculous material and after a time projects into the vesical cavity In such a calculus the large intravesical portion is separated from the encysted part by a narrow neck (" dumb-bell calculus "). Ulceration of the sac wall if it should occur is likely to lead to extravasation of urine.

The number of calculi present in a bladder varies greatly Sometimes there is only one occasionally a considerable number perhaps hundreds In such circumstances they are never of great size Multiple calculi are not infrequently faceted as a result of mutual friction.

Structure of a Calculus. A calculus usually consists of the following parts (*a*) The *nucleus* which may be formed by a portion of blood-clot, inspissated mucus or pus, a renal calculus or some foreign substance introduced from without. (*b*) The *body* which consists of superimposed layers of uric acid or oxalate of lime or of whatever substance the stone is composed not infrequently the composition of adjacent laminæ differs, leading to what is known as an alternating calculus. Each lamina consists of myriads of minute crystals held together by vesical mucus with which a certain amount of phosphatic material is often mixed, while layers of pure

phosphatic deposit may be interposed. (3) The *crust* consists of a variable amount of soft friable phosphatic material, the quantity of which is the measure of the degree of chronic cystitis originated by the calculus In some cases it is entirely absent In mulberry oxalate calculi the crust will often consist of a thin black layer of altered blood pigment.

Ætiology The causes of vesical calculus are those of urinary lithiasis in general. Some stones are found in the bladder as the result of chronic infection or obstruction and may occur in elderly men with prostatic enlargement. Others are preformed in the kidney and have migrated down the ureter The latter type is likely to affect younger individuals but rarely occurs in women whose short and wide urethræ allow the passage of relatively large calculi Chiefly because of a monotonous ill-balanced diet deficient in vitamins urinary calculi were very prevalent all over Europe until the turn of the last century and many famous figures in history were "cut for the stone." In certain parts of Asia (northern India and southern China) where semi-starvation is still commonplace the incidence of urinary lithiasis is high to-day

Symptoms. The effects produced by vesical calculi vary in different individuals according to the shape of the stone and the tolerance of the mucous membrane In children and young adults where the parts are very sensitive, even a smooth calculus gives rise to severe symptoms, but old men often tolerate a large stone without much inconvenience. An oxalate of lime calculus is usually more irritating than one composed of uric acid. The classical symptoms of a vesical calculus may be preceded by a history of the patient having passed "gravel" for a long time, or by an attack of renal colic, on the cessation of which the calculous symptoms commenced. Sometimes the vesical symptoms do not appear for some time after the passage of a stone into the bladder presumably in consequence of its small size. They consist of pain in the perineum and neck of the bladder which radiates to the back and down the thighs, but is especially noticed at the end of the penis immediately after micturition. The stone is then pressed down against the sensitive neck of the bladder by the contraction of its muscular walls. Increased frequency of micturition is also present and occasionally hæmaturia. All these phenomena are increased in severity by jolting, jumping or any form of exercise and hence are more marked during the day than at night. Occasionally the patient complains that the flow of urine suddenly ceases before the bladder has been completely emptied and that some change in the position of the body is needed in order to allow him to complete the act. In addition to these characteristic symptoms, he may suffer from various phenomena secondary to the irritability of the bladder dependent on the straining induced by the calculus. Thus tenesmus may be produced by irritability of the rectum in children and a hernia result priapism, too is not uncommon. It must be remembered that the presence of residual urine will prevent the contracting bladder pressing the stone down against the sensitive trigone at the end of micturition and thus effectively mask many of the typical symptoms of vesical calculus such as pain and hæmaturia.

The symptoms are somewhat modified in children, leading to wetting of their clothes and of their beds at night, and pulling at the prepuce and penis.

Diagnosis. A vesical calculus can be diagnosed by sounding, radiography or cystoscopy

Sounding In order to examine a patient by *sounding* he is laid on a couch with the head low and the buttocks raised on a pillow placed beneath them The bladder should always contain a few ounces, so as to obliterate any folds by laxity of the mucous membrane, as well as to facilitate the introduction of the instrument. A sterilized sound of suitable size, warmed and lubricated by some aseptic preparation, is then gently passed along the urethra, and the handle depressed between the separated legs so as to enable



FIG. 50 8. CALCULI IN THE BLADDER.

the point to enter the bladder The handle which should be cylindrical in shape and fluted with the maker s name or some mark to indicate the direction of the beak is then lightly grasped between the index finger and thumb and rotated from side to side while at the same time the whole instrument is drawn forwards or backwards in the urethra. Each side of the bladder is thus carefully investigated and, finally if no stone is detected the beak is turned directly downwards, so as to examine the pouch which often forms behind a slightly-enlarged prostate. The presence of the stone is recognized by a metallic click which can be felt and even heard when the end of the

instrument taps it The character of the click is some guide to the size and density of the stone The presence of two or more calculi is indicated by the surgeon being able to touch them on rotating the instrument alternatively to each side of the middle line or by seizing one stone with a lithotrite and using it as a sound for the other In doubtful cases, a still more delicate test than the sound is obtained by passing a medium-sized tube of a Bigelow s evacuator and washing out the bladder The calculi may by this means be sucked out even from sacculi and be felt to rattle against the end of the instrument, when the pressure upon the indiarubber bulb is relaxed. When the calculi are multiple and of small size, they may also be removed in this way by an examination which was only intended to be diagnostic in character The surgeon must not forget that a hypertrophied bladder wall with projecting fasciculi may somewhat resemble a calculus especially when coated with phosphatic material. In some rare instances a calculus may be so completely hidden in one of the saccules as to render its detection impossible by these means. An encysted calculus which projects into the bladder is recognized by being always found in the same place.

X-ray Examination This is conducted in the usual fashion care being taken to see that the rectum is empty The tube is placed over the patient s abdomen with the rays directed downwards and backwards, the film is placed below The calculus usually appears as a shadow immediately above the pubic rami

Cystoscopy This method must be used to examine the bladder in every case of stone. Indications as to the character and size of the stone can thereby be obtained and saccules or other changes in the bladder wall observed.

Complications. A patient suffering from vesical calculus is certain, sooner or later to develop symptoms of chronic cystitis, with increased pain and frequency both by day and night and the appearance of pus and bacteria in the urine. The bladder is hypertrophied, and if the stone is not removed the mucous membrane becomes ulcerated and the inflammation ascends to the kidneys.

Treatment. At the present day only three plans are employed, *viz.* lithotrity suprapubic cystotomy and very uncommonly perineal lithotomy

Lithotrity This was formerly conducted in several stages the stone being crushed and the patient allowed to pass the debris subsequently The introduction of Bigelow s evacuator in 1870 enabled it to be completed at one sitting, the proceeding being termed litholapaxy

After anaesthesia has been induced the head is kept low and a pillow placed beneath the buttocks, so as slightly to raise the pelvis. The bladder is carefully washed out with some bland antiseptic, such as a solution of boric acid and about 300 ml of lotion are left within, in order not only to obliterate all folds of mucous membrane, but also to facilitate the seizure of the stone and prevent injury of the bladder during the operation

The lithotrite is then introduced. The male blade slides easily up and down in a groove in the stem of the female blade, and after the stone has been seized it is brought to the centre of the bladder The blades are then forcibly pressed together by a screw action, brought into play by the mechanism in the handle, which can be put in and out of gear at will. When the surgeon is satisfied that the fragments are sufficiently small, the largest evacuator-tube which can be safely introduced is passed into the bladder The

evacuator is attached and the bladder thoroughly washed out by alternate pressure upon and relaxation of the rubber bottle (Fig. 50 10). By this means the fragments of the stone are collected in the glass receptacle which forms part of the apparatus. The washing is continued until no more fragments are heard or felt to rattle against the end of the tube. It may be necessary to reintroduce the lithotrite in order to crush some larger portions of the calculus still remaining. After crushing has been deemed complete the interior of the bladder should be inspected with a cystoscope to make certain that no fragments have been overlooked A certain amount of bleeding is unavoidable from these manipulations, but it is not excessive.



Fig. 50 9 Lithotrite.

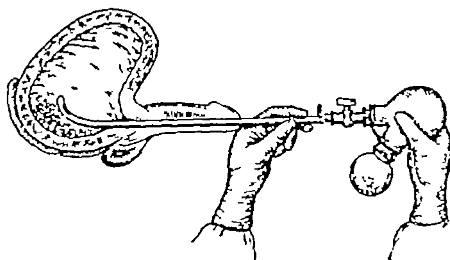


Fig. 50 10 Evacuator in Position in the Bladder.

Litholapaxy in practised hands has a low mortality and necessitates a brief stay in hospital and in suitable cases is to be regarded as the method of choice.

Contra-indications to litholapaxy are as follows

(1) Conditions of the Stone. If the calculus exceeds 3 cm. in diameter it is not advisable to attempt lithotrity on account of the damage which may be inflicted on the vesical wall in making futile attempts to crush a stone that may be too large to be grasped by the jaws of the instrument. Some stones, especially those consisting of oxalate of lime are so hard that no lithotrite can crush them Phosphatic concretions on the other hand, are so soft that a lithotrite becomes clogged and crushing is impracticable. An encysted stone will also preclude lithotrity on account of its fixed position There is no objection to dealing with multiple calculi by this means If of small size they can be removed by simply using the evacuator Stones formed around incompressible foreign bodies (metal or rubber) should always be removed suprapubically

(2) Conditions of the Urethra The existence of an organic stricture or an enlarged prostate may render lithotrity impracticable from the impossibility of passing large enough instruments whilst false passages may make it exceedingly difficult

(3) Conditions of the Bladder The existence of severe cystitis or the presence of sacculi as indicated by the cystoscope will usually suggest the performance of lithotomy a contracted bladder which will only hold a few ounces, materially increases the dangers and difficulties of lithotrity

(4) Conditions of the Kidney Severe renal infections will contradict lithotrity

After-treatment consists of catheter drainage for a few days in most cases. Post-operative infection of the urinary or genital tract is not uncommon but can usually be controlled by chemotherapy The ability of the bladder to empty itself completely should be ascertained particularly in the elderly before the patient is discharged from hospital.

Suprapubic Lithotomy This is the alternative procedure to litholapaxy and is indicated when the stone is unsuitable for crushing (e g too large) or when it is desirable to open the bladder for another reason e g to remove the prostate The bladder is washed out and 8 to 10 ounces of lotion are left within it (some surgeons prefer to open an empty bladder) the patient is then placed in the Trendelenburg position with the pelvis raised the intestines being thus allowed to gravitate to the postero-superior part of the abdomen. A median incision is made from above the symphysis upwards for 5–7 cm., the linea alba is divided and the retropubic cellular tissue opened up The anterior wall of the bladder can be readily identified by the veins coursing over its surface. An opening is then made into it in the middle line from below upwards through which the index finger is passed and the stone examined Suitably curved lithotomy forceps are introduced and the stone grasped and withdrawn. A careful examination is made to see whether any more calculi are present, as also to investigate the size of the prostate, which, if enlarged may sometimes be removed at the same time. The after treatment of the wound differs with the condition of the bladder if it is infected a drainage tube is introduced and the urine syphoned off, healing occurring by granulation in three to six weeks If the bladder is healthy and free from infection it may be closed by catgut suture. The prevesical space (of Retzius) is always drained for thirty-six hours by means of a rubber drain. Urethral catheter drainage is instituted for five or six days.

Perineal Lithotomy Once the operation of choice it was extensively employed by the itinerant "stone-cutters" and barber-surgeons until the end of the eighteenth century when it was superseded by lithotrity

Calculus in Boys. This is not a common occurrence It must be remembered that the bladder is an abdominal rather than a pelvic organ in children, and hence suprapubic lithotomy is particularly indicated, except in the hands of skilled lithotritists. It has been shown, however that lithotrity can be safely practised, and many surgeons in the East, where stone is common employ it as a routine procedure, granting that a No 6 catheter can be passed and that the stone is not too large to be grasped by a lithotrite Specially constructed instruments are required for the purpose

Calculus in the Female. As already mentioned, vesical calculus is very rare among women owing to the shortness and greater size of the urethra,

so that small stones passing downwards from the kidneys are easily voided. Phosphatic concretions are common, and may be due to the presence of a foreign body introduced by the patient.

Treatment Litholapaxy is usually indicated but for really large stones or when foreign bodies are present, suprapubic cystotomy is the best procedure It is never desirable to open the bladder through the anterior vaginal wall to remove a stone for fear of the persistence of a vesico-vaginal fistula.

Functional Derangements of the Bladder

The act of micturition is a complicated procedure, which for its effective performance requires the due co-ordination of several factors. When urine collects in the bladder it is prevented from escaping by the tonic contraction of the sphincter vesicæ in infants this is little developed, and hence readily overcome by the relatively strong detrusor in response to slight intravesical pressure. As the child grows, the sphincter becomes better developed and is under more effective control while at puberty the growth of the prostate adds to this thus micturition loses its reflex character and becomes entirely voluntary The main steps in micturition are (*a*) an appreciation of the stimuli set up in the bladder by its increasing distension, which depends on the sensory nerves having a free communication with the sensorium (*b*) as a result of this stimulus, the sphincter vesicæ (and probably also those fibres of the levator ani associated with the prostate and bladder base) are voluntarily inhibited (*c*) the detrusor muscle is contracted expulsion of the urine necessarily following. A voluntary contraction of the abdominal muscles is often employed to assist in this expulsion effort Each of these muscular elements has its own central control the sphincter in the inferior mesenteric and hypogastric plexuses, the detrusor in the lumbar enlargement of t[illegible] spinal cord, it is possible for one or both of them to be destroyed [illegible] weakened Should the sphincter control become weak, the activity [illegible] the detrusor may be relatively increased and the bladder contents are expel[illegible] too frequently (active incontinence) Should the sphincteric control [illegible] relatively increased the expulsive efforts of the detrusor will be hinder[illegible] and retention results Necessarily other causes than nervous enter into t[illegible] production of these two conditions, and hence they must be consider[illegible] separately

Incontinence of Urine. A patient is said to be suffering from incon[illegible] tinence when the urine escapes involuntarily dribbling away either con[illegible] stantly or intermittently from the urethra.

Active Incontinence (*Enuresis*) This is often present in young childre[illegible] mostly boys, in whom as already indicated, sphincteric control is not to[illegible] well developed It results from increased excitability of the urinary apparatu[illegible] and is more often found in children who are emotionally unstable Th[illegible] chief local sources of irritation are infection, phimosis, a rectal polypus an[illegible] urine of high specific gravity containing uric acid crystals in suspensio[illegible] although the importance of these factors is often overstressed The affectio[illegible] is most obvious at night and may only occur during sleep it usually di[illegible] appears when adult life is reached if not before. Rarely it persists. Th[illegible] influence of psychological and sociological factors on the ætiology of enures[illegible] are profound but lie outside the scope of a general surgical text book

Nocturnal incontinence is treated by the removal of all sources o[illegible]

irritation, such as a tight foreskin Tincture of belladonna or ephedrine should also be given in dull doses The boy should not be allowed to lie on his back or to eat or drink late at night but must be kept warm and should be waked at regular intervals to pass water During the day also the patient should be watched, and not allowed to run to the lavatory continually the bladder must be trained to hold its contents Parents and school-teachers should be instructed and their co-operation secured, so as to train the child in habits of restraint If this can be gained during the day the nocturnal habit will sometimes cease In resistant cases the help of a psychiatrist should be sought.

Passive Incontinence This is said to be present when the neck of the bladder is relaxed so that as soon as any urine is secreted it flows out of the urethra—the bladder in this way never becoming distended The cause of this condition is mainly mechanical such as the holding open of the internal meatus by a pedunculated growth or an impacted calculus It sometimes occurs in women from over-distension of the urethra as for removal of a calculus.

Senile incontinence or the incontinence of certain mental disorders is usually of this type Milder degrees of passive incontinence may be caused by weakness of the urethral and perineal musculature and are known as "*stress*" *incontinence* a few drops of urine escaping when the patient strains or coughs. This condition is very common in women after childbirth

False Incontinence or *Distension with Overflow* This may be the outcome of an attack of retention naturally relieved, or is due to any condition in which the outflow of urine is impeded to such an extent as to lead to a certain quantity being left in the bladder after every act of micturition although the patient imagines that the organ has been completely emptied. This so-called *residual urine gradually increases in amount until the bladder* becomes chronically distended and then some of it dribbles away involuntarily so as to wet the patient s clothes In old-standing cases the bladder can be palpated as a tense rounded swelling in the hypogastrium. This condition is usually met with in patients with neglected stricture or prostatic obstruction, and in the latter case the bladder may be so distended as to contain a litre or more of urine. Very much the same state of things obtains in *paralysis due to spinal cord injury or disease Treatment must be directed* to keeping the bladder emptied either by careful training, a catheter or suprapubic cystotomy The withdrawal of urine from a chronically over distended bladder should always be regarded as a serious undertaking and should preferably be done after admission to hospital Once emptied the bladder should be drained continuously and appropriate measures should be taken to combat infection and renal failure which are very prone to develop If the primary cause is a removable one (*e g* enlarged prostate) it will be found that the contractile power of the bladder will rapidly return in most cases after appropriate treatment has been carried out.

Retention of Urine. When a person is unable to expel the contents of his bladder so that it becomes distended retention is said to be present. It results from a variety of conditions which may be classified as follows

Mechanical Obstruction This may involve any part of the urethra or the neck of the bladder the actual cause varying with the age and condition of the patient. Thus, in infants the most common cause of retention is infection and œdema of a tight phimosis in children, an impacted calculus

in the urethra or a ligature tied round the penis in young men gonorrhœa or one of its complications in young women foreign bodies in the urethra or bladder in adult men, stricture in adult women uterine fibroids or some uterine condition compressing the bladder or urethra, and in old men hypertrophy of the prostate

Nervous Lesions These may be responsible for some cases. Anything that excites the sphincteric energy or diminishes the activity of the detrusor muscle may determine retention and thus it may be brought about in many ways. (*a*) Spasm of the sphincter may result from mental perturbation or excitement, a person being unable to micturate in the presence of others. (*b*) Neurosis is a common cause as in hysteria or shock and a reflex inhibition is responsible for retention after injuries or operations, especially when the latter are in the neighbourhood of the genital organs, as for piles, hernia varicocele etc (*c*) Organic disease of the nervous system produces retention by paralysis of the detrusor as in tabes, disseminated sclerosis, traumatic and neoplastic conditions of the cord etc. (neurogenic or cord bladder)

If left unrelieved, the urine accumulates and the bladder becomes distended One of two conditions is certain to follow (*a*) In cases of retention from stricture, or when a calculus is impacted in the urethra, the dilated urethra behind the seat of obstruction gives way resulting in perineal extravasation of urine If however the bladder wall has been weakened as the result of ulceration or if it be sacculated, rupture of that viscus may occur and pelvic extravasation may follow (*b*) When the retention is not due to complete obstruction of the passages the distention is in time followed by unconscious overflow and relief is obtained, although the bladder wall often becomes atonic

The treatment of retention necessarily varies with the cause The treatment of cord bladder has been greatly improved by the work carried out at the Spinal Injuries Centre at Stoke Mandeville It is found that these patients need neither catheterization nor suprapubic cystotomy in most cases. They learn to empty their bladders at regular intervals and infection is kept at bay by small doses of sulphonamide given over long periods of time.

Atony of the Bladder This term is applied to a condition in which the patient is unable to expel the contents, not on account of any true paralysis, but simply from loss of tone of the muscular wall The causes are the same as for retention and the condition may be determined by a single act of overdistension, or by the outcome of a more chronic obstruction Commonly however it is met with in old people who are suffering from long-standing retention due to enlargement of the prostate or to stricture of the urethra.

In milder degrees all that is noticed is some hesitation or difficulty in commencing the act of micturition, while the flow itself is weak, the urine escaping with no force and often dribbling away after the act is apparently completed. In long-standing cases a considerable amount of residual urine may be left in the bladder and chronic cystitis is very common

Treatment This should be directed to removing any source of obstruction which exists regular catheterization two or three times a day will prevent any distention of the bladder and the administration of carbachol may help to improve the expulsive power of the viscus. Permanent suprapubic

ystostomy may be necessary where the primary cause cannot be removed here atony persists after removal of the cause or even where no cause an be found

THE PROSTATE

Prostatitis

Acute Prostatitis. This arises most usually as a complication of urethritis ither in its acute or chronic stage by direct extension backwards of the aflammatory process it is also occasionally met with as a result of stricture r from the passage of instruments Suppuration, as in infections of the esticle is determined by the type of infecting organism thus gonococcal nfections never suppurate *Esch coli* rarely do but streptococcal and staphy ococcal infections (especially *Staph aureus*) are frequently followed by bscess-formation. Sometimes merely one or two superficial follicles are ffected, causing what is termed a follicular abscess occasionally the in- lammation extends much more widely involving the whole of one lobe or ven the whole organ, constituting a parenchymatous abscess.

Symptoms These consist of deep-seated pain referred to the neck of the bladder or a sense of weight and fullness about the perineum and pain eferred to the end of the penis. Micturition becomes frequent and painful nd defæcation may cause considerable distress. As the organ increases in ize, the pain becomes more and more severe and all movements, including he act of sitting, are increasingly difficult. On rectal examination the organ an be felt enlarged hot and tender Suppuration is likely to follow and retention of urine may be thereby induced A follicular abscess bursts into the urethra spontaneously or is ruptured by the passage of a catheter for the relief of retention *the opening, however is sometimes of a valvular* nature, so that only a small portion of the pus escapes. The process may then continue to spread and the pus find its way into the rectum or come to the surface through the perineum. In either of the latter conditions a rectal or perineal fistula is liable to result. Considerable constitutional disturbance and fever are usually associated with this affection, whether suppuration occurs or not. The formation of a parenchymatous abscess is always attended with much more acute symptoms, both general and local. The organ is larger and produces more rectal irritation a considerable quantity of pus may form, and suppuration may extend beyond the capsule

Treatment The patient should be kept in bed on a restricted diet and the bowels freely opened by saline purges. Hot baths are very valuable. Extreme pain should be relieved by the use of morphine and if the urine needs to be drawn off a soft rubber catheter of small size should be used. If an abscess forms and is not opened by the passage of a catheter or if the opening is of a valvular character so that the cavity cannot completely empty itself an incision must be made into it through the middle line of the perineum. The knife is guided by a finger placed in the rectum pus may not be reached until the knife has entered to a depth of about 5 cm. Urine will sometimes escape from this opening and may continue to do so for some considerable time. Resolution is usually rapid when adequate drainage has been established and chemotherapy is not always necessary

Chronic Prostatitis. This is one of the commonest causes of chronic gleet after gonorrhœa but may arise as a sequel of any urethral infection.

tionship of the enlargement to the so-called internal sphincter should be noted

(2) The relations to the bladder wall are altered. Normally the sphincter is interposed between the prostate and the vesical mucosa. As the gland enlarges, this relation may persist and although the bladder base is raised up the growth is extravesical and the sphincter muscle is stretched over the enlargement More frequently however the gland as it enlarges, insinuates itself between the sphincter and internal meatus, constituting an

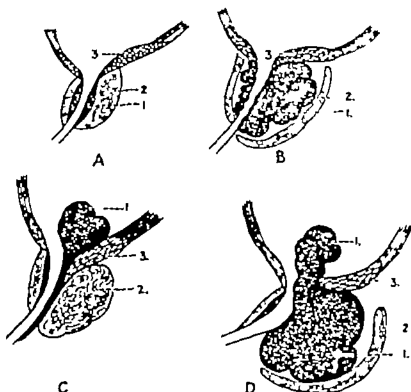


FIG. 50 11 DIAGRAMS TO ILLUSTRATE THE RELATION OF THE PROSTATE TO THE SPHINCTER VESICAE.

A. Normal prostate.
B. Subvesical glandular hyperplasia. (The enlargement is below the sphincter Note false capsule formed by compressed true prostate.)
C. Intravesical glandular hypertrophy ("middle-lobe"). The sphincter is displaced backwards.
D Combined intra- and extra vesical glandular hyperplasia.

1 Albarran's (urethral) glands.
2. True prostate gland.
3 So-called internal sphincter

intravesical projection This is generally most marked in the middle line behind constituting the so-called "middle lobe" (Fig 50 11 C) but it may involve the whole gland, which projects into the bladder as a collar-like enlargement around the meatus, while sometimes one or both of the lateral lobes are chiefly affected in this manner The gland also pushes backwards between the seminal vesicles, which in time are displaced from their connection with the back of the bladder and constitute a posterior relation with the enlarged organ. It is interesting to note that this overgrowth involves mainly if not entirely the upper part of the gland while the portion below

the verumontanum is rarely affected so that the openings of the ejaculator ducts are not displaced backwards.

(3) The changes produced in the prostatic urethra and neck of th bladder vary considerably in different cases. The length of the urethra i usually increased sometimes by as much as 5 to 7 cm or more Som amount of obstruction to the outflow of urine is universal and is due i most instances to compression of the posterior urethra by the enlarge lateral lobes. Exceptionally it may be due to an adenoma becoming pedun culated and projecting downwards into the urethra as a polypus. Chroni urinary retention once established is a progressive condition resulting i increasing amounts of residual urine and finally retention with overflov



FIG. 50 12. ENLARGED PROSTATE WITH A LARGE INTRAVESICAL PORTION. (*Royal College of Surgeons Museum.*)

When both lateral lobes are enlarged symmetrically the lumen of the urethr is diminished from side to side, being narrow or chink-like instead of tr angular but its vertical measurements are increased. Asymmetrical enlarg ments, of course, displace the urethra to one or other side Pelvic congestio in this type of enlargement due to alcohol, exposure to cold and holdir the urine too long may give rise to a sudden attack of acute retention.

(4) The effect of an enlarged prostate on the bladder is important. Th obstruction to the outflow of urine leads to increased expulsive efforts o its part, and consequently the wall becomes thickened and hypertrophie This involves the muscular fibres, which stand out prominently as rounde fasciculi and the mucous membrane may project outwards between them a protrusions, constituting saccules in which urine may stagnate, decompo and form phosphatic concretions.

In almost every case the enlarged prostate projects in some measure int the vesical cavity either as a collar-like mass around the internal meatus, c as one or more rounded outgrowths. This is necessarily associated with

pouching backwards of the lowest part of the bladder (prostatic pouch) which, being below the level of the meatus, does not become emptied during the natural process of micturition In it residual urine is therefore able to collect and remain.

Cystitis will in time follow caused either by infection from within or by the use of unsterilized instruments the bladder wall becomes inflamed ammoniacal decomposition of the urine follows and phosphatic concretions form finally renal complications ensue (due either to back pressure or to an ascending pyococcal infection) and may determine a fatal issue

Symptoms. The degree of obstruction bears no constant relationship to the size and anatomical form of the obstructing mass at the bladder neck. The patient at first finds some difficulty in micturition especially at the start of the act straining often hinders rather than assists. The stream is not necessarily smaller than formerly but is projected with less force. Gradually irritability of the bladder ensues and the patient has to pass water very frequently a trouble especially noticed during the night. Some degree of pain and sense of weight and fullness about the perineum may be experienced and hernia or hæmorrhoids induced by the straining. Intermittent attacks of increased pain and difficulty in micturition occur from time to time, generally resulting from exposure to cold and wet and presumably due to congestion of the prostate After lasting for a few days the more acute symptoms slowly disappear if judiciously treated

As the obstruction increases, a certain amount of residual urine remains within the bladder after each act of micturition, the vesical muscle in time losing power and becoming atonic. Well-marked distension and atony of the bladder ensue at length in neglected cases, the urine dribbling away and wetting the clothes. Cystitis will cause increasing vesical irritation and muscular spasm the urine becomes ammoniacal and contains muco-pus and phosphates this process, if untreated is certain to lead to hydronephrosis and pyelonephritis. The general health of the patient is slowly undermined by the constant irritation and want of sleep induced by these changes, as also by toxic absorption. The final chapter may be ushered in by symptoms of uræmia from the damage inflicted on the kidney

Occasionally the early symptoms may pass unnoticed for a considerable time, the patient imagining that the frequent calls to pass water are good signs rather than evidences of disease. In these cases the bladder may become over-distended and the condition is unsuspected by the patient even though the fundus of the bladder may reach to the umbilicus or higher At this stage overflow incontinence may develop insidiously often with surprisingly little constitutional disturbance. Acute or chronic retention may follow some indiscretion and an enormous quantity of urine accumulate in the already tolerant bladder

Diagnosis. The diagnosis of enlarged prostate is made partly by a consideration of the symptoms, but mainly by an examination of the organ from the rectum The age of the patient, the increasing irritability of the bladder by night and day the fact that straining hinders rather than helps the expulsive act, together with evidence of vesical distension—all these facts indicate that the seat of obstruction lies in the prostate. A rectal examination is done and bimanually a fair idea can be gained of the size and condition of the organ The normal prostate is about the size and shape of a horse chestnut an adenomatous enlargement constitutes a smooth rounded mass

varying in size usually soft and somewhat movable The degree of obstruction to the urinary outflow cannot be gauged from the rectum but is rather determined by the amount of residual urine This can be measured by asking the patient to empty his bladder and then passing a soft catheter merely 50 to 75 ml of urine may be withdrawn, but in advanced cases anything up to a litre may escape The actual degree and situation of the intravesical projection of the gland can only be determined by cysto-urethroscopy

The presence of a stone or stones in the bladder is indicated by severe cutting pain during micturition as also by radiography The secondary onset of cancer can only be guessed at in the early stages if the gland appears flat, hard and fixed at one spot if it commences in the centre of a lobule it is unrecognizable.

Catheterization. To pass a catheter in a case of enlarged prostate is not always easy owing to the fact that the middle lobe (Fig. 50 13) projects across

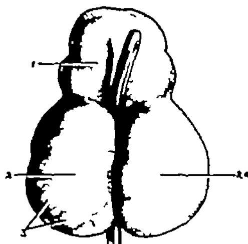


FIG 50 13 ENLARGED PROSTATE AFTER REMOVAL BY SUPRAPUBIC OPERATION.
The catheter has been placed in the urethra. 1 The so-called middle lobe, or intravesical projection behind the internal meatus 2 and 2a, the lateral lobes, 3 Indicates some of the nodular adenomatous masses which constitute the bulk of the swelling.

the urethra and bars the onward progress of an instrument of the ordinary shape. A rubber catheter should always be employed, if possible and failing that, a catheter *coudé or bicoudé* (Fig. 50 14) which consists of a soft straight instrument of the usual French type, the end of which is bent or doubly bent at an angle, like an elbow so as to enable it to ride over the obstruction Tieman s catheter (Fig. 51 5) which is made of firm rubber and has an olivary pointed upturned (coudé) end, combines all the advantages of both types

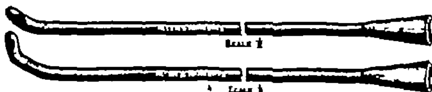


FIG. 50 14 CATHETER COUDÉ (*a*) AND BICOUDÉ (*b*).

of catheter and is invaluable for the catheterization of patients with enlarged prostates. Only in difficult cases associated with acute retention should the surgeon resort to the silver prostatic catheter which is longer and more curved than usual and the handle of which requires to be well depressed between the thighs after the point has cleared the pubic arch Whichever method is adopted no force is required, since with a little skill the point of the instrument will pass round the obstruction and enter the bladder Every precaution must be taken to ensure the sterilization of all instruments, and it should be remembered that as a rule large rather than small instruments will pass more easily

After catheterization a certain amount of fever may be produced, which either passes off in a few days, or may increase together with symptoms of chronic cystitis.

The urinary infection which eventually follows repeated catheterization of patients with enlarged prostates can be mitigated by chemotherapy but this effect is often temporary as the organisms may become resistant to the various drugs or else fresh invaders, such as *Proteus* and *Ps aeruginosa* which are difficult to control, make their appearance Hence catheterization should never be looked on as more than a temporary expedient (e g to tide the patient over a crisis such as pneumonia) and surgical relief of the obstruction must be the main objective in every case however advanced the obstruction and however decrepit the patient.

Treatment of Enlarged Prostate. Expectant treatment can be recommended in early cases where there is no evidence of infection or other complication. The patient should be advised to avoid alcohol and exposure to cold and to empty his bladder regularly and completely The state of the urinary tract (including the presence of gross amounts of residual urine) can most conveniently be determined by intravenous pyelography Instrumentation should be avoided because of the danger of infection but cystoscopy to exclude bladder-growths or diverticula is justifiable when hæmaturia or pyuria are present.

In the majority of cases, however when the patient has well-defined symptoms of prostatic disease including much residual urine he will probably prefer to undergo operative treatment. Some little discrimination is required in case selection and pre-operative investigation. In suitable cases the operation is best undertaken in one stage Preliminary bladder drainage either by catheter urethrostomy or cytostomy may be necessary to improve renal function or to tide the patient over a crisis (e g pneumonia cardiac failure) until prostatectomy is considered safe

Before the surgeon decides to proceed to operative measures the patient must be fully investigated to determine his fitness and the nature of the gland to be removed Rectal examination will give some idea as to the size and consistence—this can be confirmed by cystoscopy when the intravesical projection of the gland will be observed, the residual urine measured and a catheter specimen sent for bacteriological investigation As already stated instrumentation in these cases is not free from risk however and many prefer to carry out a cystoscopic examination in the operating theatre as a preliminary to the actual operation The renal function will be decided by means of a urea concentration test and blood urea some surgeons prefer to rely entirely on intravenous pyelography

however Provided the patient has a mobile prostate satisfactory renal function tests, no cardiac or pulmonary or other contrary indications prostatectomy can be advised

For many years suprapubic prostatectomy was regarded as the routine method of treatment for the enlarged prostate. Other methods such as perineal prostatectomy and perurethral resection either by punch or loop have many enthusiastic advocates. Endoscopic procedures have a lower mortality rate but the functional end-results are inferior to those of open operation Improvements in the technique of all types of operation are constantly being made and the approach to the prostate gland by the retropubic route has now found many adherents. Each of these methods has certain technical advantages over the others and will yield the best results in certain circumstances, *e g* when the urethra is small and the obstruction large, some form of open operation is preferable to perurethral resection the converse is equally true. In planning operative treatment many factors, both local and general, need to be considered and the surgeon who gets the best results is the one who is prepared to vary his technique to suit the patient and the type of obstruction from which he is suffering.

Suprapubic Prostatectomy This in its simplest form consists of transvesical blind enucleation of the obstructing adenoma with a finger in the posterior urethra aided if necessary by counterpressure with the forefinger of the other hand in the rectum (Freyer s method) The bladder is drained by a large suprapubic tube to facilitate the removal of blood-clot and packing of the cavity is sometimes employed to control hæmorrhage. Modifications of the original technique of Freyer (1901) have been introduced by Thomson Walker Harris, Wilson Hey and others. These modifications are aimed at better control of hæmorrhage and reduction of infection so as to permit complete closure of the bladder incision. Earlier ambulation a shorter and vastly more comfortable convalescence rather than any dramatic lowering of the mortality rate are the chief advantages of these modifications.

Retropubic Operation In this operation introduced by Millin (1946) the bladder neck is approached directly *via* the space of Retzius which is freely opened up A transverse incision is made in the false capsule anteriorly which is deepened until the plane between the pearly white adenoma and the surrounding capsule is found. Enucleation is then performed from the front instead of from above This operation has certain advantages over the transvesical methods, the chief of which are the better exposure it usually gives of the prostatic cavity better hæmostasis and the fact that the bladder is not opened means that its function is less impaired.

Perineal Prostatectomy Though never extensively employed in this country it is still popular in some American and Continental clinics. Its main advantage is the very low mortality rate, permitting its use in the feeblest of patients. Disadvantages are the dangers of incontinence from injury to the external sphincter and of damage to the rectum In certain selected cases the operation will yield gratifying results, provided the operator is skilled in perineal surgery

Perurethral or *Endoscopic Operations* In this country perurethral resection is most commonly carried out by the McCarthy resectotome (Fig. 50 15), although a punch can be used with equal success. Resection consists of the removal of pieces of prostatic tissue through a large endoscope by means of a wire loop electrode, using a cutting current under vision.

This is rendered possible by the McCarthy visual system and irrigation. Sterile water must be used for this purpose with no electrolytes to disseminate the current. This should be carried out by a surgeon extensively skilled in cystoscopic manipulations, as in inexperienced hands it may lead to per

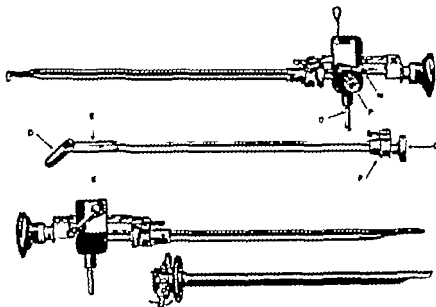


FIG. 50 15 MCCARTHY RESECTOTOME, SHOWING ITS COMPONENT PARTS

foration of the bladder into the peritoneal cavity or into the rectum. This method is best suited to the removal of smaller adenomata *e g* " middle-lobe " enlargements or to relieve muscular or fibrous bladder neck obstructions. It is sometimes used to excise prostatic carcinoma infiltrating the

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PLATE 11

1 CYSTIC CYSTITIS.

The cysts occur in a healthy or slightly inflamed bladder they are discrete and not confluent. Most commonly found as the result of chronic inflammation in parous elderly females. Not to be confused with bullous cystitis.

2. BULLOUS CYSTITIS (ŒDEMA).

The bullæ are confluent and hyperæmic, and less translucent than the cysts of cystic cystitis found in cases of tuberculosis and carcinoma and after radium treatment. (From a case of carcinoma vesicæ.)

3 TUBERCULOSIS.

A slightly retracted right ureter is seen with a tuberculous ulcer above The white shining nodule is a tubercle.

4 PYONEPHROSIS.

Thick pus is exuding from the orifice of an inflamed ureter The bladder around shares in the hyperæmia.

5 PAPILLOMA.

Note a gradual change from long, slender *fern-like processes to a shorter more fleshy* type (an early stage in malignant change). The star of pale radiating striæ is a scar resulting from fulguration of a papilloma. The present growth is a recurrence six months after treatment by fulguration.

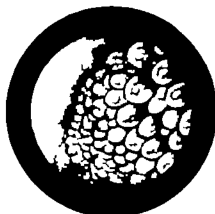
6. ENLARGED PROSTATE

A view of an enlarged middle lobe seen in the mid-line on the floor the bladder is seen in the distance over the hill of the prostate This type is suitable for trans-urethral resection.

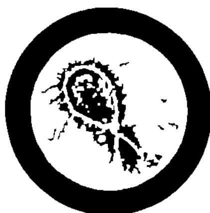
PLATE 11



1



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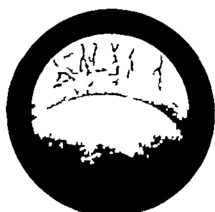
3



4



5



6

CYSTOSCOPIC APPEARANCES.

TO FACE PAGE 1288

bladder neck as an alternative to suprapubic cystostomy in those cases where retention fails to respond to œstrogens The urethra must be adequate in size to permit the introduction of the large instrument otherwise the incidence of stricture will be high and when this occurs the patient will merely exchange one form of urinary obstruction for another

Any bleeding at the time of operation is controlled by changing to a bulbous electrode and coagulating under vision with the diathermy current

If preliminary drainage has been established the operation is in no way altered and the urethral catheter will need to be reintroduced after about a week to allow closure of the suprapubic wound The after treatment is much the same as for closed prostatectomy the catheter being introduced at the conclusion of the operation and frequent irrigations being advisable The catheter is usually removed on about the fifth day The patient is allowed up in a few days provided no complications have occurred

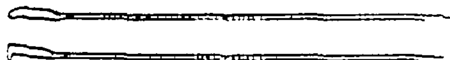


FIG 40 16. DIATHERMY ELECTRODE AND CUTTING LOOP ELECTRODE.

Foley s catheter is often used for post-operative drainage By tract on on the distal end of the catheter the inflated bag exerts pressure on the bladder neck and will often control post-operative hæmorrhage As it requires no tapes strapping or other retentive apparatus it is ideal for prolonged bladder drainage either pre or post-operatively

Suprapubic Cystostomy This is frequently indicated mainly as a preliminary to either prostatectomy or perurethral resection Both these operations require satisfactory renal function tests before they can be embarked on with safety The patient therefore with poor tests should have temporary drainage established and have his urea concentration test and blood urea done at regular intervals until improvement occurs

Permanent suprapubic cystostomy is now very rarely indicated for prostatic obstruction, except in certain cases of carcinoma where it is not possible to introduce the resectotome owing to the tortuous and lengthy rigid urethra, and in certain cases of benign enlargement where the renal function does not improve sufficiently for resection or prostatectomy to be carried out.

In these cases a De Pezzer or Malecot catheter is introduced through a small suprapubic incision it may be connected to a portable urinal worn in the trousers Most patients, however are happier when the tube is plugged with an ordinary wooden spigot which can be released at regular intervals to allow the escape of urine Regular bladder washouts will be needed to keep the bladder clean Boiling and replacement of the suprapubic tube should also be carried out at least once a fortnight.

Vasotomy This is carried out by most surgeons in all types of prostatectomy as a routine prophylactic measure against epididymo-orchitis. The vas is divided and ligated about 2 cm above the globus major of the epididymis on both sides.

Bladder-Neck Obstructions

Bladder neck obstructions (Marion's disease) are a group of diseases which cause symptoms of prostatic obstruction but in which there is no real enlargement of the prostate gland (*prostatisme sans prostate*). The *bladder-neck* is a surgical rather than a strictly anatomical term and is applied to the outlet of the bladder which comprises the internal urinary meatus the adjacent bladder wall and the posterior urethra as far as the veru montanum Opening of the bladder neck during micturition is brought about by a passive relaxation of the circular muscle of the so-called internal sphincter combined with a rise of intravesical tension due to contraction of the muscles of the abdominal wall and the detrusor muscle of the bladder Various conditions may cause disturbances of micturition by preventing this normal "opening" mechanism. They include fibrosis of the bladder neck from long-standing prostatitis, congenital hypertrophy of the internal sphincter and proliferation of the submucous glands of Albarran ("middle lobe" enlargement)

The effects of bladder neck disease are similar to those observed in simple prostatic obstruction except that the duration of symptoms is usually much longer before medical advice is sought.

Diagnosis. This is made by the absence of prostatic enlargement and the presence of a "bar" on the posterior aspect of the internal meatus, readily recognized on cystoscopy Diverticulum of the bladder will be found associated with about half of the cases and hydroureter in nearly one-third.

Treatment Dilatation of the posterior urethra with large bougies is used in early cases, but removal of the obstruction either by excision of the bladder neck or by perurethral resection will be required if the obstruction is at all severe, or when glandular hyperplasia is observed.

Carcinoma of the Prostate

Carcinoma of the prostate is one of the commoner forms of malignant disease in elderly males. Young stated that four men out of every hundred who live to sixty years of age will have cancer of the prostate but more recent researches on this subject indicate a much higher incidence (40 per cent. according to some observers), many of the tumours being symptomless. The age incidence is the same as that of benign enlargement and about 20 per cent. of patients with symptoms of prostatic obstruction will be found to be suffering from carcinoma. According to the histological appearances two main groups are distinguished, the adenocarcinoma and the scirrhus. The latter is more slowly growing and by far the commoner In it fibrous tissue is abundant and glandular tissue relatively scanty Spread takes place by the lymphatics which pass upwards and backwards towards the iliac and sacral lymph-nodes on the side-wall of the pelvis. The strong fascia of Denonvilliers acts as an effective barrier to direct backward spread to the rectum Skeletal metastases are common and involve the pelvic girdle and lumbar vertebræ in about 20 per cent. of cases. Irregular new bone formation is common and in advanced cases the pelvis may become of marble like consistence (Fig. 50 17). Obliteration of the marrow-cavity may result in secondary anæmia. Visceral metastases, chiefly in the liver or lungs are often observed at autopsy In the more advanced cases, particularly those with widespread metastases, the serum acid phosphatase levels are frequently raised. The normal upper limit is three King Armstrong units.

The symptoms produced are generally those of prostatic obstruction but once established they progress more rapidly than those of benign enlargement. In some cases initial symptoms are due to metastases (e g bone pains, sciatica, spontaneous fracture, etc.) and urinary symptoms may be slight or absent On rectal examination the gland is stony hard and often irregular in consistence Periprostatic spread will obliterate the lateral border of the gland and bilateral hard ridges can often be palpated above and laterally in the region of the seminal vesicles. In the later stages a diffuse hard fixed mass can be felt infiltrating the whole prostatic area and bladder-base When no instruments have been passed the urine is invariably crystal-clear

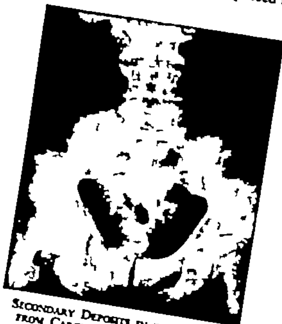


FIG. 50 17 SECONDARY DEPOSITS IN THE PELVIS (OSTEOBLASTIC) FROM CARCINOMA OF THE PROSTATE.

Treatment Radical removal is rarely possible because there is nearly always evidence of extra-prostatic spread when the patient is first seen. The operations described which consist in removal of the entire prostate, seminal vesicles and part of the bladder-base by the perineal route (Young) or retropubically (Millin) are only likely to be successful in early localized growths. Palliative measures alone can be adopted in the majority of cases. Relief of urinary obstruction must be afforded either by perurethral resection or by suprapubic cystostomy Severe nerve root pains can be alleviated either by caudotomy or the injection of absolute alcohol into the spinal theca

The main form of treatment for prostatic cancer to-day is the giving of stilboestrol, 5–150 mg. daily which affords excellent symptomatic relief to many patients and halts or even causes regression in tumour growth. The rationale for this therapy is the work of Huggins, who showed that prostatic cancer needs androgens (produced by testes and adrenals) for growth. Castration, usually performed as a subcapsular orchidectomy is also valuable for the same reason. Bilateral adrenalectomy and hypophysectomy are not as effective in this disease as they are in breast cancer but cortisone 25–50 mg. daily often leads to relief of pain and a sense of well-being.

THE URETHRA AND PENIS

THE URETHRA

Congenital Absence This, together with occlusion of the urethra has been met with, the urine in such circumstances being sometimes retained and leading to dilatation of the bladder, ureters and kidneys, a condition rapidly fatal, even if the child be born alive. In a few cases the urachus remains patent and a congenital urinary fistula is established at the umbilicus in others the cloacal condition persists, the rectum communicating with the bladder

Diverticulum. A diverticulum may exist in the anterior urethra and form a valvular obstruction when it fills with each act of micturition Treatment by excision is required before the affects of retention cause damage by back pressure

Epispadias. This is a deformity in which the urethra is partially or wholly exposed along the upper surface of the penis. In rare instances the external meatus is situated just above the glans, which is cleft and deeply grooved superiorly More commonly the urethra opens at the root of the penis, just in front of the symphysis and in such patients the organ is always rudimentary and stunted. Complete epispadias is only present when associated with extroversion of the bladder The incomplete form has been treated with success by the use of reversed flaps dissected up from the side of the penis.

Hypospadias. This consists of the defective development of the lower wall of the urethra and is a much more common malformation than the foregoing. Three varieties are described

(1) *Hypospadia Glandis* In this the opening of the urethra corresponds to the position usually occupied by the frenum and is thus directed downwards instead of forwards. The prepuce in these cases is always voluminous and hangs like a hood over the glans which is bent down over the orifice

(2) *Hypospadia Penis* *This is characterized by the urethra opening* somewhere along the under surface of the body of the penis, which is often small and stunted. Spraying or other difficulties may arise in the act of micturition owing to the urethral orifice looking downwards the opening is also sometimes so small as to require incision and dilatation

(3) *Hypospadia Perinealis.* *This is a somewhat complicated* condition in which the lower wall of the urethra is defective as far back as the perineum the scrotum being cleft and thus resembling the vulva (Fig 51 1) The penis is always small, imperfectly developed and bound down by adhesions between the scrotal segments. It looks like a hypertrophied clitoris and late descent of the testes is common. Under these circumstances it is *not* surprising that the sex of the child has been mistaken, and cases are on record where the boy has been educated as a female until the age of puberty

Chromosomal sexing of the child by means of a skin biopsy or blood smear is of particular value in these circumstances

Treatment In the incomplete varieties where the deformity is slight and the urethral opening on the glans no treatment is necessary All other degrees of hypospadias require correction in order to allow normal micturition and effective sexual intercourse The operations of Ombrédanne and Denis Browne are employed and details will be found in the chapter on Pædiatric Surgery (Chap 39).

Carcinoma. When this occurs in the urethra it is usually secondary to some other malignant focus in the neighbourhood, *e g* in the prostate Very rarely however it is primary and then frequently the sequel of an old stricture It constitutes a hard swelling of the urethra which infiltrates surrounding parts and there is usually some discharge of blood and pus from the meatus micturition is consistently painful. The introduction of an instrument increases both the pain and the bleeding it generally passes easily but the irregularity of the surface of the growth can be recognized. Examination by the urethroscope is desirable in such cases. The prognosis of this type of tumour is poor mainly because it is rarely diagnosed in the operable stage. Owing to fairly rapid involvement of the pelvic lymph nodes radiotherapy is of limited value

Injuries to the Urethra

Injuries to the urethra are fairly common in the male but exceedingly rare in females The male urethra may be injured from *within* (*e g* by the passage of instruments) or from *without* (by direct trauma to the perineum or indirectly in cases of fractured pelvis). External wounds involving the urethra are rare, even in war time.

The rupture may be *complete* or *incomplete* according to whether the tear involves the whole circumference of the urethra or whether part of it

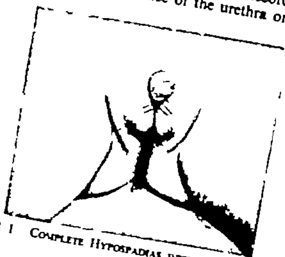


FIG. 51 1 COMPLETE HYPOSPADIAS WITH CLEFT SCROTUM.

is intact. In the anterior urethra the tear may involve one or more of the three distinct anatomical layers *i.e* the mucous membrane the spongy tissue or the fibromuscular sheath and injuries are often classified as internal, interstitial or external, according to the depth of the lesion

There are three common clinical types of urethral injury

Injuries from Within. These are usually inflicted by the surgeon in an attempt to advance an instrument when its point is no longer in the lumen of the urethra or (less commonly) by the use of excessive force in the ex traction of an impacted urethral calculus or foreign body The result is either a laceration of the mucous membrane or else a tunnelling (false-passage) of the corpus spongiosum or the parenchyma of the prostate gland. The rupture is thus an incomplete one, its depth depending on the amount of force used. Such an injury will always give rise to free hæmorrhage and some times retention of urine infective complications (catheter fever) periurethral or prostatic abscess, pyelonephritis (septicæmia etc.) may follow when trauma has been severe This type of injury is largely avoidable and prevention lies in the exercise of care and the acquisition of skill in the passage of instruments.

Treatment This consists of measures to relieve the symptoms, such as

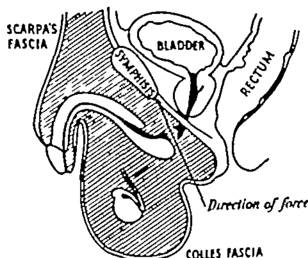


FIG. 51 2. RUPTURED PERINEAL URETHRA (COMPLETE) WITH EXTRAVASATION BELOW COLLES'S FASCIA.

hæmorrhage retention, etc., as they arise but local repair of this type of rupture is rarely necessary

Ruptured Anterior Urethra. This usually results from violence applied directly to the perineum as by falling astride a hard object or by a kick or blow in this region. The rupture generally involves the bulb about 1 inch distal to the triangular ligament It is usually complete but in some cases a portion of the superior aspect of the urethra will remain intact. The clinical signs are characteristic enough to make the diagnosis obvious in the majority of cases. Local pain at the site of injury is rapidly followed by hypogastric pain if retention of urine develops. A hæmatoma forms rapidly in the perineum and spreads out towards the gluteal regions, assuming a charac teristic "butterfly" shape Urethral hæmorrhage varies inversely as the degree of rupture If complete, blood will tend to track into the loose periurethral tissues rather than along the urethra. Hæmorrhage is always more conspicuous in incomplete ruptures, especially when the strong fibromuscular sheath is intact. Retention of urine will occur in complete ruptures but the patient may succeed in passing urine if it is incomplete

In the former case attempts to pass urine will be followed rapidly by an extravasation of urine below the triangular ligament, similar to that observed in cases of stricture.

Treatment In the slighter cases where it is probable that only the mucous membrane has been torn and there is no perineal swelling, the patient should be kept quietly in bed, and no attempts made at instrumentation. If infection of the wound occurs and an abscess forms, it can be dealt with by incision at a later date.

When however it is thought that the urethra is partially or wholly divided no temporizing measures, such as tying in a catheter even if that be possible, should be adopted An incision ought to be made at once into the perineum so as to expose the divided ends of the urethra, which it is the surgeon s aim to unite. The blood-clot is removed, bleeding-points are secured If the ends of the urethra can be identified a soft catheter is introduced into the bladder and they are sutured together around it with fine catgut. When the ends are much bruised, they should be excised so as to have clean, smooth surfaces to deal with. The catheter is removed after the anastomosis has been completed and the skin approximated with adequate provision for drainage of the suture line. It is essential to combine this with suprapubic bladder drainage to divert the urine from the damaged area this also affords the opportunity for the retrograde passage of a catheter to identify the proximal end of the torn urethra when it is difficult to find.

If a catheter cannot be introduced, or if extravasation has occurred, free incisions must be made into the scrotum and perineum to give exit to the blood and urine, and to expose the seat of injury A catheter is passed as far as the rupture its point felt for cut down on, and the instrument guided into the bladder if possible. Immediate end-to-end anastomosis may be possible but where infection or œdema have caused extensive sloughing it may be wiser to rely on suprapubic cystostomy and free drainage of the perineum in the first instance and defer the urethral repair until the operative field is free from infection.

Ruptured Posterior Urethra. This can only occur as a result of external trauma when the integrity of the pelvic girdle is destroyed. Hence the injury is only observed as a complication of fractured pelvis, occurring in about 5 per cent. of cases. The mechanism is nearly always the same, viz a violent backward displacement of the posterior urethra and base of bladder at the time of fracture The posterior urethra is torn across at the apex of the prostate just above the fixed membranous urethra. The clinical signs are not so characteristic as in anterior ruptures but mistakes are unlikely to occur if urethral injury is suspected in every case of fractured pelvis. Urethral hæmorrhage is slight or absent but it is often possible to squeeze a few drops of blood along the urethra. Retention of urine is constant but may be overlooked in a severely shocked patient. Hæmatoma and extravasation are concealed at first as the accumulation takes place above the triangular ligament (Fig. 51 3) On rectal examination it may be possible to feel an area of fullness and bogginess below the base of the bladder suggesting the presence of blood or extravasated urine. Lastly a catheter will be obstructed in the posterior urethra and, on rectal examination, its tip may be felt lying somewhere outside the line of the urethra.

Treatment The urgency of operative treatment is much greater than

with other forms of urethral injury It is essential to *restore continuity* of the widely separated ends of the severed urethra without delay otherwise the technical difficulties become greatly increased Direct suture from the perineum may be attempted but most surgeons rely on some form of internal splinting by means of a self retaining urethral catheter together with continuous traction. Numerous ingenious methods of accomplishing this can be found in text-books of operative surgery *Two other essentials* in the treatment of ruptured urethra are firstly the need for diversion of the urine by suprapubic cystostomy and secondly proper reduction of the fractured pelvis to permit restoration of the damaged soft parts to their normal anatomical position.

Foreign Bodies. These are sometimes found in the urethra, usually consisting of a portion of a catheter a pipe-stem or in children a piece of crayon. Their presence gives rise to partial or complete obstruction to the flow of urine followed by ulceration of the mucous membrane, the formation

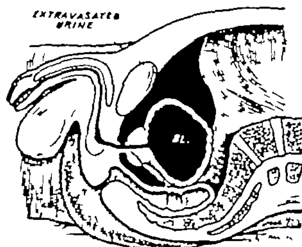


FIG 51 3 EXTRAVASATION OF URINE DUE TO A RUPTURED POSTERIOR URETHRA.

of a periurethral abscess, or even extravasation. They are readily detected on the passage of a sound or catheter and may be removed by suitable forceps if situated near the orifice. Should this fail, the urethra may be incised and the body extracted Incision of the penile urethra may give rise to persistent fistula in spite of careful suturing and for this reason urethrotomy at or distal to the peno-scrotal junction should be avoided where possible

A pin is sometimes introduced intentionally into the urethra and is not easily removed, since it has usually been pushed in head foremost The following manœuvre is necessary in order to remove it The point is made to penetrate the floor of the urethra and skin by a sharp push on the head from behind The body is pulled out until the head catches against the mucous membrane and then the direction of the pin can be changed so *that the head presents at or towards the meatus*

Impacted Calculus. This may cause retention in children It can usually be felt through the walls of the urethra. The symptoms and treatment

are much the same as for foreign bodies. When near the neck of the bladder it should be pushed back into the viscus if possible and treated by lithotrity

Non-Specific Urethritis

Non-specific urethritis includes all non-gonococcal infections of the urethra. The causes are numerous but most cases will fall into one of the following three groups

Simple Urethritis. Primary urethritis, as it is also called, is a disease running a very similar though much milder course than gonorrhœa The discharge is less profuse with fewer pus-cells. Various organisms such as staphylococci diphtheroids, micrococci etc., may be found but it is doubtful whether these are really pathogenic. The ætiology is obscure. Many regard the disease as venereal in origin being transmitted to the male from an infected female cervix. Certain cases of non-specific urethritis are complicated by arthritis and conjunctivitus and to these the term *Reiter s syndrome* has been applied

About 50 per cent. of cases respond well to intravenous arsenicals, in others urethro-vesical irrigations with a mild antiseptic may effect a cure. Tetracycline and chlortetracycline by mouth or ACTH by intravenous infusion is often effective in curing the symptoms of Reiter s syndrome

Secondary Urethritis. This is generally due to some form of urethral irritation. The commoner exciting causes are a tied-in catheter intra urethral injection of strong chemicals foreign bodies or calculi Descending infections from foci in the kidney bladder or prostate may also involve the urethra. Certain specific fevers and syphilis (in all three stages) may also give rise to a secondary urethritis. The treatment is that of the primary cause.

Post-gonococcal Urethritis (*Gleet*) *This is the term applied to a chronic* non-specific urethral infection following an attack of gonorrhœa. This condition is due to unskilled or inadequate treatment of the primary infection. In many cases a focus of infection will be found in the prostate, seminal vesicle, or Cowper s gland. *Intra urethral lesions such as chronic littritis* intra-meatal warts or even urethral strictures are not uncommon. The treatment is on similar lines to that of simple urethritis but any local pre disposing cause (*e g* stricture) must first be corrected. Penicillin may be of value in those cases where gonococci are thought to be lurking in the deeper tissues.

Intra-meatal Warts. These are similar in character to the caruncle met with in the urethra of women and have been observed at the orifice of the male urethra. They are red, vascular and sometimes exceedingly painful. They are dealt with by excision, followed by the application of diathermy so as to stop the bleeding, which is always copious. If of large size, the base may be ligatured and the growth cut away

Stricture of the Urethra

By stricture of the urethra is meant a condition in which the onward passage of urine is hindered owing to some change in the walls of the urethra, which prevents them from dilating. When at rest, the urethra is merely a potential canal, the walls of which are in complete apposition, and it is only converted into a tube when urine is passing along it. When, owing to some change in the structure of its walls, this functional dilatation

is impracticable the patient is said to suffer from stricture Three forms of stricture are described, *viz.* the spasmodic, congestive and organic.

Spasmodic and Congestive Strictures. These frequently coexist, although either congestion or spasm may be the predominant feature in any particular case Thus in acute gonorrhœa the mucous membrane often becomes engorged and thickened to such an extent as to interfere with the act of micturition. Spasm is the chief element under the following conditions (*a*) When a patient suffering from slight organic stricture is exposed to wet or cold, especially after heavy drinking (*b*) as a result of catheterization and (*c*) from perineal irritation of the urethra, as by a blow or kick in this region. Temporary retention is the usual result of any of these conditions, *and as a rule, no treatment is required beyond the local application of heat* in the form of baths, enemata compresses, etc. If such fails, catheterization will be necessary and must be conducted with the greatest gentleness, owing to the congested and easily injured condition of the mucous membrane. Full-sized soft instruments should first be used and will usually succeed if not, a silver catheter must be substituted.

Organic Stricture. This term is applied to an undilatable condition of the urethra, due either to congenital narrowing (*congenital stricture*) or else to the development of cicatricial tissue within its wall (*acquired stricture*).

Congenital Stricture. This occurs at either extremity of the urethra, *i e* at the external meatus or in the posterior urethra at the level of the veru montanum. The former condition is often referred to as " pinhole meatus " and is by far the commoner The contracted meatus is readily detected by simple inspection, but in young infants it may be masked by the presence of a meatal ulcer napkin rash and balanitis.

The mother's attention may be drawn to the condition by persistent bed wetting or by pain and difficulty of micturition This condition is rarely observed in uncircumcized infants, in fact the prepuce is believed by many to have a protective function during the napkin stage Treatment consists of local relief of balanitis. Meatotomy may be necessary later In adults a mild degree of meatal stenosis may be relieved by dilatation alone.

Posterior congenital strictures are rare. They are often associated with the formation of flaps or valves in the region of the veru montanum. These conditions give rise to an accumulation of residual urine in the bladder and are often " silent " until incontinence of overflow develops about the second or third year Gross dilatation of the upper urinary tract and commencing renal failure are generally present when the patient is first seen and, for this reason, the prognosis is bad In favourable cases it is sometimes possible to relieve the urethral obstruction by a retropubic approach, but prolonged suprapubic drainage is usually necessary to enable the dilated upper urinary tract to recover

Acquired Strictures. These may be due to a number of causes the most important of which are as follows (*a*) The long continuance of urethritis following gonorrhœa or the frequent recurrence of this affection. Chronic inflammations are always characterized by a tendency to sclerosis of the tissues involved and the urethra is no exception to this rule its walls under these circumstances becoming thickened, indurated and contracted Gonococcal strictures usually develop in the bulb, about 1 inch (2 5 cm) distal to the triangular ligament. They are often multiple and may involve the greater part of the bulb extending even as far as the penile urethra (*b*) The

cicatrization of a urethral chancre or of an ulcer caused by the impaction of a stone or the contraction produced by the healing of a urethral abscess may also lead to stenosis (c) The most intractable forms of stricture are those due to cicatrization after rupture or laceration of the urethral wall

Various terms are applied to a stricture according to the physical conditions present thus, it is termed *annular* if it involves the whole lumen of the urethra *bridled* if it affects only a portion of the circumference of the tube. A *ribbon-shaped* stricture is one in which a considerable extent of the wall is contracted, *i.e* as if a ribbon has been tied around the urethra It is termed *tortuous* if the resulting passage is not straight *indurated* if the walls are very hard and thickened and *resilient* when the stricture, though readily dilated rapidly recontracts The terms *impassable* and *impermeable* are applied to strictures through which, on the one hand, a surgeon is unable to pass an instrument or along which, on the other hand urine cannot find its way it is doubtful whether the latter condition ever occurs, while the number of impassable strictures met with by the surgeon diminishes with his experience and ability in passing instruments.

Pathology The pathological conditions arising from a stricture are best considered under the following five headings (a) The *urethra anterior* to the stricture is usually in a perfectly normal state although possibly the orifices of false passages may be seen A few granulations are sometimes present, projecting at the commencement of the stricture (b) The *stricture itself* is characterized by the development of fibro-cicatricial tissue immediately under the mucous membrane and intimately adherent to it. It extends for a variable distance and is often associated with a good deal of periurethral infiltration (c) The *urethra behind the stricture* is dilated and the mucous membrane velvety and friable the orifices of the lacunæ and other glands are somewhat enlarged and more than usually evident, and ulceration may be present around them In the later stages the inflammation may extend to the periurethral tissues owing to lymphatic absorption or perhaps to the escape of a few drops of urine a perineal abscess then results leading subsequently to perineal fistulæ. When the obstruction becomes almost absolute, this portion of the urethra may give way leading to extravasation of urine into the perineum and scrotum (d) The *bladder* invariably manifests considerable changes in structure At first the vesical wall undergoes a compensatory hypertrophy of its muscular elements and is thickened in order to overcome the obstruction to the onward passage of urine. The lattice work arrangement of the muscular bands becomes coarse, thickened and evident, causing the vesical wall to assume a fasciculated appearance. As the pressure increases, the mucous membrane protrudes between the muscular fasciculi, giving rise to sacculation it is also thickened and congested as a result of chronic cystitis the superficial veins become varicose and hæmaturia may be caused by their rupture ulceration may also occur The urine becomes alkaline and decomposes containing muco-pus and phosphates. It is likely to stagnate in any sacculi which exist and may then determine the formation of phosphatic concretions or the walls of the sacculi ulcerate, and after a time perforate with extravasation of urine into the cellular tissue Occasionally the bladder instead of being thickened is dilated and atonic, with very thin walls. (e) Consequent on the changes in the bladder the conditions already described as hydronephrosis, pyonephrosis, or pyelonephritis may develop partly as the result of the backward

pressure and partly from the extension of inflammation along the ureter to the pelvis of the kidney and calyces.

Symptoms The symptoms of urethral stricture vary according to the case The patient generally complains of difficulty in the act of micturition, the stream becoming small and perhaps forked or twisted It takes a longer time than usual to empty the bladder and even when apparently successful a few drops of urine may trickle away wetting the patient s clothes. Irritability of the viscus follows, leading to frequent attempts to pass water at short intervals during the day and night The urine under these circumstances often becomes alkaline and loaded with muco-pus and phosphates. As the obstruction increases, more and more residual urine is left in the bladder which may in time form a tense, rounded, dull swelling in the hypogastrium. The quantity of urine trickling away also increases, so that the patient s *garments are always wet, giving him an unpleasant urinous odour* A certain amount of gleety discharge is present and if the individual takes an excess of alcohol, or is exposed to wet and cold complete retention may ensue. Sometimes the onset of the symptoms is so insidious that such an attack of retention is the first marked feature in the case

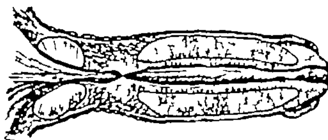


FIG. 51 4 ANNULAR STRICTURE OF THE BULBOUS URETHRA.

Physical Examination The actual diagnosis of a stricture can only be confirmed by a careful physical examination of the urethra which is usually made by the introduction of a full-sized catheter or a solid bougie *e.g* No 9 *or 10 (English) so as to ascertain where the obstruction is situated* If this cannot be passed smaller instruments, or even filiform bougies, are inserted until one is found which will enter the bladder Rigid bougies (usually stainless steel) and flexible bougies (of gum-elastic or plastic materials) are used for purposes of diagnosis and treatment of strictures by dilatation

Gum-elastic catheters are often sterilized by keeping them in a box with formalin tablets The catheters, however must be washed through with weak boracic or sterile water to remove deposit *of formalin from* the interior and exterior of the catheter as this substance readily sublimes and is very irritating Alternatively they may be allowed to soak for *twenty minutes in a* 1 in 2,000 oxycyanide of mer[illegible] solution.

Neither of these methods can be entirely r[illegible] ensure sterility Fortunately the better [illegible] gum-elastic insti[illegible] now be boiled. The use of a special c[illegible] heated formali[illegible] another reliable method, but only sui[illegible] hospital clin[illegible]

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Bougies or solid instruments are preferred by the majority of surgeons for examination and treatment of strictures Lord Lister s are still popular consisting of solid metal rods curved like catheters the bulbous ends of which are three sizes smaller than the shanks, thus enabling each instrument to prepare the way for the next.

If these fail to pass, a filiform bougie made of gum elastic is introduced If this fails several more are introduced simultaneously into the urethra and each will block up a pit or even a false passage so that ultimately one will find its way through the stricture When this has been done a Harrison bougie can be screwed on to the connection at the end of the filiform bougie which will then guide the passage of the larger instrument If necessary a Phillips catheter which is similar in design except that it has a lumen for the drainage of urine can be used if a full bladder is present



FIG. 51 5 TIEMAN'S CATHETER.

Bouginage In order to introduce a silver catheter or bougie, the patient is laid on his back the surgeon standing on his right side The umbilicus should always be exposed as also the upper parts of the thighs The meatus and the end of the penis are washed with a 1 in 2,000 solution of sublimate as also the surgeon s hands. The catheter which has been previously sterilized, warmed and covered with sterilized or antiseptic oil or grease, is taken in the right hand and inserted into the urethra with the handle directed over the left thigh and slightly downwards. The point of the instrument is guided as far as the perineum and then the handle is carried round to the middle line of the body towards the umbilicus it is gently raised to the vertical, the penis being held in the left hand, and finally depressed between the patient s thighs, the so-called *tour-de-maître* The catheter finds its way along the urethra into the bladder rather by its own weight than by a forcible action of the surgeon The chief points at which difficulty may be experienced are (*a*) The orifice, which may be small and contracted (*b*) the lacuna magna, which is avoided by keeping the point of the instrument against the floor and (*c*) the opening in the triangular ligament, which is best entered by keeping the point against the upper wall of the canal

When a flexible instrument without a stilette is used, it is passed by pressing the point on with a little rotatory movement until the bladder is reached, withdrawing a little, and pushing on again if any obstruction is met In some instances, however the use of a stilette is absolutely necessary

Dangers of Instrumentation. These are as follows

Shock A considerable degree of shock is sometimes experienced especially in sensitive individuals if an instrument has not been passed before It may be obviated to a large extent by first introducing a few ml. of lignocaine jelly into the urethra.

Hæmorrhage This may be induced by laceration or abrasion of the mucous membrane even though no false passage has been made it is best avoided by gentleness and the use of well-finished instruments. In spite of these precautions, when the mucous membrane is soft and congested and in

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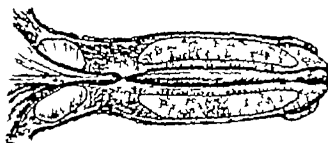


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Neither of these methods can be entirely relied on to ensure sterility Fortunately the better types of gum-elastic instrument can now be boiled The use of a special cabinet with heated formalin-vapour is another reliable method but only suitable for large hospital clinics.

The most popular rubber catheters are Marshall s or Tieman s (Fig 48 5), the latter being useful in prostatic cases, as it is made of particularly firm rubber and its beak is coudé to engage the curve of the urethra

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Hæmorrhage This may be induced by laceration or abrasion of the mucous membrane, even though no false passage has been made it is best avoided by gentleness and the use of well finished instruments In spite of these precautions, when the mucous membrane is soft and congested, and in

many cases of stricture, some bleeding cannot be avoided. It is rarely sufficient to call for special treatment but if very abundant may be arrested by the pressure of an instrument tied in, by pressure on the perineum or by an ice-bag applied to the scrotum When severe the passage of urine from the bladder may be prevented by the presence of clots ("clot retention"), and if these cannot be evacuated through a large catheter then suprapubic drainage may be necessary

False Passages These are occasionally produced in the treatment of strictures The point of the instrument is most likely to leave the canal at some spot in the floor travelling for a variable distance, according to the force employed under the mucous membrane, sometimes re-entering the dilated urethra behind the stricture which it avoids altogether or perforating the posterior wall of the bladder by tunnelling under the prostate, an accident which can only occur in unskilled hands The occurrence of a false passage is indicated by the sudden onward movement of the instrument, combined with pain and hæmorrhage the point is usually deflected from the middle line as is plainly seen by the obliquity of the rings at the end of the shaft no urine comes unless the urinary passages are opened behind the stricture. On rectal examination, the instrument can be felt out of the middle line, and nearer the rectum than is normal, and in some exceptional cases has even been found in it. A false passage is not necessarily a matter of great importance but when extensive may lead to periurethral suppuration and extravasation of urine If the urine is very offensive grave infective troubles may arise even threatening life.

Inflammation This may be lighted up in the prostate and acute epididymitis induced by extension along the vas deferens.

Urinary Fever This is sometimes termed, urethral or catheter fever and is always liable to develop as a result of the introduction of instruments. It may occur as a solitary rigor even in individuals with healthy urinary organs but is much more frequently observed in those with urinary infections. As to its causation much discussion has arisen but there can now be little doubt that it is essentially infective in origin It is quite sufficient for a slight abrasion to occur near the neck of the bladder or in the vicinity of the corpus spongiosum to allow the absorption of bacteria and then general phenomena show themselves at once. Possibly a passing febrile condition, with one or more rigors will develop with no more serious phenomena but the trouble is liable to be more widespread in certain cases giving rise to pyelonephritis or even septicæmia

The clinical manifestations vary considerably according to the character of the case and the type of infection. (*a*) The simplest form consists in the development of a single rigor the temperature perhaps running up to 105° F the patient shivers and feels very ill complaining of headache but when the temperature falls he soon recovers, and within a few hours is all right again. (*b*) Sometimes the temperature does not fall to the normal after the initial rigor but remains elevated a few degrees for a day or two and there may even be a repetition of the rigor The patient however recovers perfectly and no permanent harm is done (*c*) In the more serious cases the symptoms of pyelonephritis supervene, and may even prove fatal, the patient dying in seven or eight days (*d*) General pyæmia may appear as a complication of the last condition. (*e*) Finally suppression of urine may accompany any of the conditions alluded to above

The greatest care must always be taken in order to avoid infection, it is better to use soft instruments if possible rather than metal ones in patients who are prone to catheter fever

The patient should be instructed to drink plenty of fluid and to avoid alcohol for twenty-four hours after instrumentation and when catheter fever is known to have occurred on previous occasions he should be given a course of chemotherapy It has been shown that bladder washouts will greatly reduce the incidence of febrile reactions in cases where the urine is heavily infected and if marked chronic urinary retention is present continuous catheter drainage of the bladder for a few days after the dilatation of a stricture is a valuable prophylactic measure Anuria following instrumentation is nearly always due to renal infection (pyelonephritis) Prompt and vigorous treatment, consisting of catheter drainage, intravenous injections of glucose or sodium sulphate (3 7 per cent.) and chemotherapy should be instituted.

The Treatment of Strictures. *Dilatation* Treatment by dilatation is effected in various ways according to the nature of the stricture and the urgency of the symptoms. Where the obstruction is not serious and an instrument can be easily passed, *gradual dilatation* should always be employed this consists in the use of instruments once or twice a week, steadily increasing in size until a No 12 is reached If the intervals are too short the urethra may become irritated spasm be induced and the lumen of the canal temporarily diminished in size by keeping the patient quiet for a few days on a bland diet, and the bowels freely open the spasm disappears. In cases where time is an object, *rapid dilatation* may be undertaken by the passage of several sizes of bougie at one sitting for this purpose Lister s instruments are particularly useful. Where only a very small catheter can be introduced and that with difficulty *continuous dilatation* may be adopted by keeping the patient in bed, and tying in a small instrument for forty-eight hours or more, at the expiration of which period a catheter several sizes larger can be substituted. This in turn may be tied in if the patient can bear it but the presence of a catheter within the urethra for any length of time is not always tolerated, and may give rise at the end of two or three days to considerable constitutional disturbance and fever

By whichever of these methods dilatation is accomplished it is essential that the surgeon should subsequently pass an instrument through the stricture, at first every week or two and then at longer intervals to overcome the tendency to recontraction which is ever present.

Excision. This is certainly the ideal treatment, the urethra being thereby restored to a normal condition. It has now been frequently undertaken, and with great success, in strictures of the deeper perineal portion of the urethra it is not so satisfactory when the penile urethra is involved. Gonococcal strictures can rarely be successfully excised because they are generally multiple. Traumatic strictures are, on the other hand, strictly localized and excision will often bring about a complete cure Fully an inch of the tube may be excised, and the ends sutured together over a catheter The corpus spongiosum must be detached from its surroundings to permit of this Sutures are introduced in the upper wall first then the catheter is placed in position and the remainder of the stitches inserted Extensive strictures may be excised and a neat urethra formed after the method used by Denis Browne in children with hypospadias (see Chapter 39).

Internal Urethrotomy This is a valuable means of treatment when rightly employed, but in careless or inexperienced hands may be attended with considerable danger It should never be undertaken for impassable strictures, and therefore it is limited to strictures through which at least a filiform sound can be passed, and yet for various reasons ordinary dilatation is undesirable Thus it may be required (*a*) in the treatment of very old and dense strictures, as also (*b*) for resilient strictures, and (*c*) when the urethra is so irritable that the passage of any instrument is associated with grave constitutional reaction. (*d*) Occasionally the patient cannot give the time to submit to ordinary treatment by dilatation and in order to hasten matters internal urethrotomy may be desired.

The operation is usually performed from before backwards and Thomson Walker's urethrotome (Fig. 51 6) is usually employed After irrigating the urethra, a special staff is introduced to which is attached terminally a fine filiform guide, which passes through the stricture and coils up in the bladder Along a groove in the staff is inserted a steel rod carrying a triangular knife, sharp at each end with the apex blunt and expanded, so as not to injure the urethral wall during its passage. When the knife engages the face of the

FIG 51 6. THOMSON WALKER'S URETHROTOME.

stricture its onward progress is hindered, the surgeon then drives it forward with a sharp push, thereby dividing the fibrous wall of the stricture this is usually effective along the roof of the urethra Several sizes of knife are available so as to vary the depth of the incision. A full-sized soft catheter is passed and tied in being retained for two or three days the patient is then permitted to micturate normally and no instrument is passed for a fortnight. Hæmorrhage sometimes occurs and is not easy to control Ice to the perineum and pressure may be helpful but in serious cases the urethra must be explored

External Urethrotomy This is also known as Syme's operation and is required under circumstances similar to those needing internal urethrotomy but is chiefly employed when complications arise behind the stricture, such as a perineal abscess perineal fistulæ impaction of a calculus, or extravasation of urine. It is performed by passing a special shouldered staff grooved in the midline (Fig. 51 7), the distal end of which is small enough to traverse the stricture. The shaft of the instrument is of larger size and ends abruptly so that the shoulder rests against the face of the stricture the groove extends on to the larger portion for about ½ inch (1 cm) The patient is then placed in the lithotomy position and the surgeon seated opposite the perineum, which is shaved and purified, incises it in the middle line

The incision is deepened carefully so as to reach the groove in the staff behind the stricture The knife is then carried forwards to the anterior extremity of the groove and inasmuch as it extends on to the shaft of the instrument, the stricture is completely divided Any fistulæ which exist are laid open into the median wound A full-sized soft catheter is then passed into the bladder through either the penis or the perineum according to circumstances, and retained in position for some days the urine being syphoned off in the usual way the perineal wound after hæmorrhage has



FIG. 51 7 SYME'S SHOULDERED STAFF FOR EXTERNAL URETHROTOMY

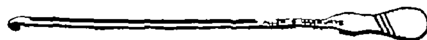
been stopped is packed and allowed to heal by granulation The catheter is removed early or late according to the amount of general disturbance caused thereby, subsequently a full-sized instrument can be passed into the bladder daily

Treatment of Impassable Stricture This varies according to whether or not the condition is complicated with retention of urine.

If no retention is present it is possible that the inability to pass an instru-



FIG. 51 8 WHEELHOUSE'S OPERATION FOR IMPASSABLE STRICTURE.



SCALE ½

FIG 51 9 WHEELHOUSE'S STAFF

ment is due to some temporary spasm or congestion induced by errors of diet or drink or perhaps by exposure to cold Hence the patient should rest in bed for a few days, his bowels be well opened, the diet regulated, and a mixture containing some alkaline purgative administered. Further attempts at instrumentation should then be made, if necessary under an anæsthetic, and if the stricture still remains impassable, Wheelhouse's operation (Fig. 51 8) is indicated. This consists in incising the urethra in

front of the construction, tracing the passage backwards, and dividing it. A Wheelhouse a straight staff (Fig. 51 9) with a median groove and a blunt hook at the end is inserted down to the stricture, and the urethra opened just in front of it by cutting down on the groove. The staff is then twisted round, the upper end of the incision drawn up by the projection of the hook, and the sides of the urethra held apart with artery forceps. The orifice of the stricture is thus exposed and granulations may often be seen projecting from it. A fine probe-pointed director can generally be insinuated along the urethra through the stricture, which is then divided. A full-sized instrument is passed into the bladder and retained for a few days, and the wound is allowed to heal by granulation.

If *retention of urine is present* in a case of impassable stricture no time must be lost. If seen at an early stage, and the symptoms are not urgent, the patient is given a hot bath. The bowels are opened by a warm enema, and a moderate dose of morphine is administered. If the urine is not passed naturally in the bath, and the bladder is becoming distended, being felt in the lower part of the abdomen then suprapubic cystotomy must be performed. Bougies or soft instruments are passed from inside the bladder if not at once, at any rate after a day or two. Dilatation then proceeds in the usual manner.

Periurethral Abscess. This may occur as a complication of stricture and is due either to a limited extravasation of urine or to the absorption of infective material through an ulcerated surface. It is indicated by the formation of a hard brawny swelling in the perineum or above the scrotum, which is tender to the touch. As it approaches the surface, fluctuation can be detected and the skin over it becomes congested and œdematous. Constitution disturbance and fever are also present. Left to itself it bursts and usually gives rise to a perineal sinus or fistula discharging either pus or urine mixed with pus. One or many of these fistulæ may occur and the openings are not limited to the perineum, but may also be found in the thighs or buttocks. In chronic cases, the scrotal or perineal tissues become infiltrated and of an almost cartilaginous consistence.

Every abscess in the scrotum or perineum is not necessarily associated with stricture for simple irritation of the skin may lead to a superficial abscess suppuration in the lacunæ or Cowper's glands, may follow gonorrhœa a prostatic or ischiorectal abscess may point in the perineum and the injury inflicted by the passage of instruments, or the existence of false passages, may lead to a similar result.

Treatment This consists in letting out the pus through a free incision and it is often advisable to take the opportunity of dealing radically with the stricture by incision at the same time. Perineal fistulæ associated with urethral stricture tend to close spontaneously when the latter has been adequately dilated and excision of the fistulous track is rarely called for.

Extravasation of Urine This condition is due to a solution of continuity of the urethral walls allowing the urine to find its way into the perineal and scrotal tissues. It usually results from over-distension of the urethra behind a neglected stricture during some violent effort at micturition, the patient experiences severe pain and a sensation as if something had given way in the perineum followed by a feeling of relief. This, however is of short duration as it is soon succeeded by the local and constitutional effects of extravasation. Occasionally the onset of symptoms is more gradual being

preceded by a periurethral abscess which bursts into the urethra at each act of micturition the cavity becomes more and more distended with urine finally the wall yields resulting in diffuse extravasation The same phenomena are produced in cases of traumatic laceration of the urethra if the patient attempts to empty his bladder Extensive laceration of the urethra by unsuccessful instrumentation is a frequent cause of urinary extravasation

The membranous urethra is almost always a site of the rupture, the urine finding its way subsequently through the anterior layer of the triangular ligament, and being guided towards the anterior abdominal wall by the arrangement of the fasciæ. The root of the penis, covered by its appropriate muscles, lies in an interfascial cul-de-sac, formed by the anterior layer of the triangular ligament above and the deep layer of the perineal fascia (or fascia of Colles) below these two layers are continuous, passing round the transversus perinei muscles, and are both attached laterally to the ischiopubic rami. Into this space the urine finds its way after the anterior layer of the triangular ligament has yielded and owing to the fact that its passage backwards and laterally is checked by the attachment of the fasciæ it is necessarily forced forwards, infiltrating in order the perineum scrotum, and body of the penis. If more extensive it travels along the spermatic cords to the anterior abdominal parietes, its passage downwards into the thighs being prevented by the attachment of the deep layer of the superficial fascia of the abdomen to the fascia lata just below the inguinal ligament In the most severe cases the urine may even find its way as far as the axillæ

The effects of extravasation of urine following a stricture are always serious, inasmuch as it is almost certain to be foul and alkaline, and hence wherever it travels it gives rise to a gangrenous cellulitis. The parts at first become infiltrated and brawny but soon necrosis of the cellular tissue occurs. The congested and œdematous skin turns to a dusky purple or black colour and finally gives way or separates allowing exit to a mixture of pus, urine and decomposing slough of a most offensive and penetrating odour The superficial loss of substance may be so extensive as to lay bare both testicles, and even the body of the penis, or part of the anterior abdominal wall. The inflammatory process is necessarily associated with severe constitutional disturbance, at first characterized by high fever and a quick, bounding pulse but later on the temperature may become subnormal and the patient profoundly collapsed from toxæmia

Treatment This consists in early and free incisions, so as to give exit to the urine and pus and to prevent, if possible, the sloughing of the skin and subcutaneous tissues Every part that the urine has infiltrated must be dealt with in this way thus the perineum should be incised in the middle line the scrotum is similarly divided, if need be, down to the urethra, the testes being laid bare on either side but if possible this should be avoided. The penis should be incised when necessary on either side of the urethra, and along the dorsal surface. A full-sized catheter must be passed into the bladder and to effect this the urethra has often to be laid open and the stricture divided perineal drainage is always preferable for these cases. The parts should be subsequently dressed with gauze soaked in flavine, hypochlorite, or hypertonic saline solution. Frequent baths may be employed and a continuous sitz-bath is very valuable for a short time. As soon as the wounds become clean, they should be dressed in the ordinary way to allow them to granulate.

THE PENIS

Phimosis. This common condition is one in which the prepuce cannot be retracted over the corona In infants up till the age of three years a varying degree of phimosis often associated with adhesions to the glans and an elongated narrow foreskin is to be regarded as the normal state, in fact an important function of the prepuce would appear to be that of protecting the glans while the infant is still incontinent Loss of this protection will in some infants lead to balanitis, meatal ulceration and meatal stenosis. After the age of three the prepuce appears to undergo further development whereby it becomes more mobile and most of the adhesions to the underlying glans are absorbed.

It will thus be appreciated that circumcision is extremely rarely necessary on purely medical grounds before the age of three, the only indication being occlusion of the opening of the prepuce sufficient to cause real urinary obstruction. Circumcision should be recommended after the age of three for hygienic reasons (*i.e* inability to retract the prepuce for washing) or when the orifice of the prepuce is narrow enough to predispose to paraphimosis. There is no doubt that the irritation set up by accumulated dirt or secretions under the prepuce can frequently cause inflammatory metaplastic or even neoplastic changes and for this reason the early instruction of all uncircumcised males in proper habits of personal hygiene is essential.

Treatment The operation of circumcision is performed as follows The dorsal aspect of the prepuce is put on the stretch by grasping it on either side of the median line with a pair of catch forceps a director is then introduced between it and the glans and held exactly in the middle line and the prepuce slit up with a scalpel or scissors The lateral halves are now separated from the glans adhesions if necessary being broken down, so as to enable all retained smegma to be removed and the corona glandis defined. The redundant preputial tissue both skin and mucous membrane is cut away on each side by scissors, special attention being directed to the removal of sufficient tissue on the underside to prevent the unsightly projection so likely to follow In adults several arteries will require to be ligatured especially that in the frænum, but in a child the hæmorrhage is slight Having carefully trimmed up the edges and snipped off ragged corners, so as to render the margins of the wound regular catgut sutures are inserted to prevent any raw surface being left exposed In children only a few are required, but possibly a considerable number in adults a continuous suture should never be employed. The wound is dressed with strips of gauze and around this a wisp of sterile wool retained in adults by a narrow bandage Considerable after trouble is sometimes experienced from nocturnal erections, which may be so marked and prolonged as to tear through the stitches to control this sedatives may be administered. Stilbœstrol by mouth, 5 mg. daily for a few days is also effective The stitches are usually removed at the end of five days, and the parts are then dusted over with a mixture of powdered boric acid zinc oxide and starch so as to reduce their sensitiveness.

Paraphimosis. When a phimosed prepuce is completely retracted the patient often finds it impossible to replace it thus giving rise to a condition known as paraphimosis It is due to the narrow orifice of the prepuce getting behind the corona, and is characterized by great œdema and congestion not only of the exposed mucous membrane, but also of the glans

itself If left untreated ulceration takes place along the line of constriction and the parts become fixed in their deformed position the vessels sooner or later accommodating themselves to the new conditions, and the œdema slowly disappearing. In some cases sloughing of the glans may occur

Treatment This consists in forcible replacement of the prepuce This is accomplished by grasping the penis between the first and second fingers of each hand and compressing the glans penis with the thumbs so as to empty the vessels and diminish the amount of œdema present and thus reduce its size (Fig 51 10) At the same time the fingers draw the prepuce forwards and thus finally reposition is effected When the œdema of the prepuce is very marked it should be punctured in several places to permit the escape of serum and diminish the tension previous to reduction as just described Injection of hyalase may also help In more advanced cases reposition becomes impossible and then the narrow constricting band caused by the



FIG. 51 10 REDUCTION OF PARAPHIMOSIS.

orifice of the prepuce must be divided on the dorsal aspect. This will free the parts, which can be subsequently drawn forwards, and after the œdema has been reduced by applying lotio plumbi for a few days circumcision may be advantageously undertaken

Balanitis. This consists of inflammation of the glans, may be simple in nature arising from want of cleanliness in a person with a long foreskin, but is sometimes associated with gonorrhœa, soft chancres or even carcinoma The under-surface of the prepuce is often involved and then the term balanoposthitis is sometimes applied to it. A purulent discharge escapes from under the prepuce which is often swollen and œdematous Occasionally when a considerable degree of phimosis exists, the under surface of the prepuce may become ulcerated, and even perforated allowing the glans to protrude through its upper surface

Treatment In simple cases all that is required is to cleanse the parts thoroughly by washing beneath the foreskin and then to apply lead lotion on lint between the glans and the prepuce but when there is much discharge and the foreskin is long and swollen or if perforation is threatening, the

prepuce must be slit up and after the parts have been restored to a healthy state the redundant tissues cut away by a modified circumcision.

Syphilitic Chancre and Soft Chancre These conditions are described with venereal diseases in Chapter I

Herpes. This condition may affect the prepuce and glans It manifests itself as a crop of small vesicles on a hyperæmic base, which become abraded, leaving a number of small ulcers It is preceded by neuralgic pain, and accompanied by much itching and irritation The only treatment required is to keep the parts clean and dust them over with powdered oxide of zinc and starch. In the majority of cases the disease lasts from a week to ten days.

Penile Warts. These often arise on the penis in the shape of red, vascular excrescences usually pedunculated and sometimes of considerable size. They are met with most frequently as a sequel of gonorrhœa and must be carefully distinguished from mucous tubercles They should be treated by snipping away with scissors and cauterizing the base with diathermy



FIG. 51 11 GONORRHŒAL WARTS.

Application of mild caustics such as trichloracetic acid or podophyllin in mineral oil are effective in most cases X rays are also useful in their removal when very extensive.

Sebaceous Horns. These are occasionally seen arising from the body of the penis They should be excised

Carcinoma of the Penis. This neoplasm is nearly always due to lack of proper hygiene in the uncircumcized It is rare before middle age and is often preceded by chronic balanitis or leucoplakia due in the first instance to irritation by dirt or retained secretions. It usually commences in the sulcus behind the corona glandis and slowly spreads to the surrounding parts, manifesting itself either as an irregular papillated wart-like out growth, or as a diffuse infiltration, ulcerating early and leading to consider able destruction of tissue (Fig. 51 12). At first the prepuce becomes distended producing a sanious discharge which contains epithelial cells as well as pus later on both the prepuce and the body of the penis are invaded and owing

to its great vascularity the disease makes rapid progress The inguinal nodes are early affected but when the body of the penis is involved the lumbar nodes may become implicated Circumcision is usually necessary before a diagnosis can be made and in view of the difficulties of distinguishing the diverse epithelial lesions found under the prepuce a biopsy should be taken in every case before treatment is decided upon

Treatment The treatment of choice for limited growths confined to the distal part of the organ is irradiation This may be given externally by telecurie apparatus or X rays or by the interstitial implantation of radium needles. A suprapubic cystostomy is sometimes necessary if the urethra is invaded The lymphatic field connected with the penis ought also to be dealt with either by surgery or irradiation as in any other case of cancer Excision is not difficult to effect as regards the inguinal nodes, but dissection of the iliac or para-aortic nodes is a more extensive procedure. Oblique incisions are made in either groin and through these the nodes together



FIG. 51 12. CARCINOMA OF THE PENIS.

with the vessels and fat surrounding them, are gathered up and turned down and in towards the root of the penis, where, if amputation is to be total, they can be taken away together with the body of the penis in one portion without division of the lymphatic trunks. Unfortunately lymphatic œdema of the legs may develop after this procedure if it be thorough.

If irradiation fails or for any other reason is considered unsuitable, amputation must be done. Partial amputation is an operation of but little difficulty The skin around the organ is divided by a circular incision and retracted a little. The corpora cavernosa are then cut through and the corpus spongiosum divided half an inch lower down Bleeding is arrested by securing the divided vessels, five ligatures are usually required, viz one for the artery to each corpus cavernosum one for each dorsal artery and one for the artery to the septum. The fibrous sheaths of the corpora cavernosa are than overstitched, so as to close the vascular spaces, and the urethra split on its inferior aspect for about a centimetre. The skin on the underside of the penis is similarly incised in a longitudinal fashion and the urethral mucous membrane is stitched to it The remainder of the incision is closed in the usual way

Amputation of the whole penis is a more serious operation. The patient is placed in the lithotomy position and the perineum is incised freely in the middle line. The corpus spongiosum is traced backwards and divided at such a level as to allow the mucous membrane lining the proximal portion of the urethra to be stitched to the skin at the posterior angle of the incision. The corpora cavernosa are freed from their connections and separated at their origins from the ischio-pubic rami by the knife or suitable raspatories. An elliptical incision is then made round the root of the penis, the dorsal vessels are divided and secured and the suspensory ligament cut through. The penis can then be drawn forwards and completely removed All bleeding points are ligatured and the anterior wound closed by a continuous suture in the middle line a drainage-tube being placed in the perineal portion for a few days. This operation may be combined with block dissection of the lymphatic fields on both sides *The results of this operation are fairly* satisfactory and by the use of a suitable contrivance the patient need not assume the sitting posture in order to micturate. He can carry about with him a small metal funnel bevelled to fit the perineum with a spout directed forwards

Chapter 52

THE TESTES, SEMINAL VESICLES AND SCROTUM

THE TESTIS AND CORD

Congenital Affections

Many congenital abnormalities of the testes are due to the fact that they are not developed in the scrotum but from the posterior wall of the abdominal cavity so that they lie at first behind the peritoneum close to the kidneys. Each gonad arises from the so-called genital ridge which is covered by columnar epithelial cells and lies to the medial side of the Wolffian body. The vasa efferentia are developed from the tubules of the latter structure coming into relation at a later date with the seminal tubules the vas deferens is formed by the Wolffian duct.

Occasionally the testis is entirely absent and a few cases are on record of absence or deficiency of the vas. Very rarely two testes develop on one side and both find their way into the scrotum (*polyorchism*).

The passage of the testis from the abdominal cavity to the scrotum takes place at about the end of the eighth month of intra-uterine life. The gubernaculum testis assists in this process, but whether its function is to direct or to effect the descent is still doubtful. It consists of a band of involuntary muscular fibres which traverses the inguinal canal and is attached above to the posterior peritoneal wall of the abdomen and possibly to the testis, below to the abdominal wall pubis and the bottom of the scrotum. The gubernaculum is supposed to exert traction on the testis and peritoneum, thereby determining the formation of the tunica vaginalis in the first place and the descent of the testis slightly later.

Two chief forms of malposition of the testis are described, arising either from its incomplete or abnormal descent.

Incomplete Descent or Retention of the Testis. The testis may remain in the abdominal cavity attached to the abdominal wall by a mesorchium (*retentio abdominalis*) more frequently it is found just within the internal abdominal ring (*retentio iliaca*) but most commonly it occupies the inguinal canal, or lies just outside it (*retentio inguinalis*). The organ in the latter position is freely mobile, being readily pressed upwards superficial to the inguinal canal where it appears to lie in a definite pouch between the deep fascia and the external oblique aponeurosis. By careful manipulation it can often be brought downwards into the scrotum. This latter condition is very common and is often referred to as a "retractile" testis. It is most important to recognize it in order to avoid an unnecessary operation as the retractile testes will descend spontaneously at puberty. The cause of these conditions must be looked for in some defective action of the gubernaculum. They are easily recognized by the absence of the testicle in the scrotum, and in the inguinal variety the organ can usually be detected as a small movable swelling about 1 5 cm in diameter. The scrotum on the affected side

may be poorly developed. In any of these varieties a late descent of the testis may occur usually accompanied by a congenital hernia.

Malposition of the Testis or Ectopic Testis. This occurs when a testis descends to some position other than its proper one in the scrotum. The gubernaculum has been described as having five extensions, only one of which enters the scrotum *The other four lead to the sites at which an* ectopic testis may be found.

Superficial Inguinal This is by far the commonest variety of ectopic testis, the organ being palpable just medial and superior to the external *inguinal ring. It is easily palpated at this site and cannot be manipulated* into the scrotum

Femoral This, the rarest variety is seen when the testis enters the thigh beside the femoral vessels

Perineal This also is uncommon. The testis lies in the perineum where it is readily detected and where it makes sitting painful.

Lateral In this variety the testis passes laterally towards the anterior superior spine of the ilium between the layers of the anterior abdominal wall. It may carry with it a patent process of peritoneum to produce one variety of interstitial hernia.

Complications of Maldescent. It is true to say that an undescended *testis is usually an imperfectly developed organ while an ectopic testis is* frequently a normal one An undescended testis often has an attenuated mesorchium, widely separating the testis and epididymis and even in the adult its spermatogenic function is impaired or absent The undescended *testis is particularly prone to undergo torsion and is possibly more liable to* malignant change than the normally placed one The ectopic testis is also liable to torsion and is particularly exposed to trauma.

Treatment of Maldescent. Treatment requires careful judgment and, if *operative intervention is necessary proper timing.* Accurate diagnosis is essential for all ectopic testes require operative treatment to place them in the scrotum and to deal with any coexisting hernia. Undescended testes if bilateral, may be left alone until puberty *i.e when the voice breaks and axillary hair makes its appearance. At this age many of them will descend* spontaneously If the child is obese dieting may result in marked development of the penis and descent of the testes. If the testes are still undescended a course of *six bi-weekly injections of 5 000 international units* of gonadotrophin should be given intramuscularly Since gonadotrophins can produce sexual development at any age they are best reserved until the patient is fourteen or fifteen years old.

Orchidopexy This operation is relatively easy in cases of ectopic testis. A crease incision is made over the inguinal canal and a finger used to burrow down into the empty scrotum The testis is mobilized from where it is *lying and if far away e g in the perineum a second incision will have to be* made over it. The testis is then drawn gently into the inguinal wound its cord and blood supply being protected and a silk ligature passed through its lower pole, a straight cutting edge needle being left on each end of the ligature. Each needle *is then passed down into the scrotum,* out through its lowermost point and the ligature pulled on until the testis is in its proper place. The ligature should be attached to the thigh through the medium of a piece of rubber glove so that *for the first few post-operative days* the testis is retained in the scrotum.

Many methods in addition to the one described above, have been devised to retain the testis in the scrotum after operation Ombrédanne's operation consists in passing the testis through the scrotal septum to the opposite compartment. Torek's operation involves two stages at the first the testis is stitched to the deep fascia of the thigh and the scrotal edges sutured to the thigh wound A few months later the scrotum is detached from the thigh.

In all these operations attention must be paid to any hernial sac which may be present. The sac should be carefully dissected out, tied off at its neck and removed

Torsion of the Testis. This is a common complication of imperfect descent owing to the long mesorchium. This condition has been confused with a strangulated hernia although a mistake of this kind is unlikely to occur if the scrotum is carefully examined Torsion of the fully descended testis within the tunica (intravaginal torsion) may occur where there is a long mesorchium

Inversion of the Testis. In this uncommon condition the epididymis lies in front and the body of the organ behind It is of no clinical significance, except that in careless hands the testis may be injured in tapping a hydrocele.

Torsion of the Spermatic Cord. Acute strangulation of the testicle results from this. The cause still remains unknown, but some have been associated with late descent of the testis and others have been attributed to twists and strains The condition is generally observed during adolescence or early adult life, although it has been reported as late as the fifth decade The symptoms are fairly characteristic the patient complains of an acute sickening pain in the testis which persists until gangrene has supervened the pain may then disappear It is accompanied by mild pyrexia and the appearance of a tumour in the scrotum

The testis is usually found to be enlarged to twice its normal size, the overlying skin at first becoming œdematous and, after a day or two adherent over a fairly wide area. Pain may be severe at the onset but rarely persists longer than a few hours this is followed by rapid loss of all testicular sensation as necrosis takes place. Progressive diminution in the size of the organ will follow complete torsion until the testis is finally represented by a small fibrous nodule. Partial atrophy of the testis has been described after one or more attacks of incomplete torsion, although this condition is by no means common. Torsion of the spermatic cord is probably the commonest cause of atrophy of the testis and because of the mildness of the symptoms, the diminished size of the organ is often attributed by the patient to some trivial injury In some cases bilateral involvement may occur and in these delayed secondary sex changes may be observed

Treatment For this to be effective a torsion must be recognized and dealt with in less than twelve hours of its onset. Closed reduction of a torsion of the spermatic cord can sometimes be effected by rotation of the testicle (usually two and a half turns) in the direction which will relieve the pain. Open reduction will be necessary for most cases. Subsequent fixation of the tunica or testis to the back of the scrotum will prevent further attacks of torsion. Orchidectomy should be performed only when the testis is completely infarcted.

Torsion of the Appendix Testis. Of the vestigial structures attached to the globus major of the epididymis the stalked hydatid of Morgagni is

prone to undergo torsion on its elongated pedicle giving rise to a cherry-like and exquisitely tender nodule at the upper pole of the testis. Severe pain or repeated torsion may call for excision of the structure, which at operation will be found to consist of a tense little sac often filled with blood-stained fluid

Injuries to the Testis and Cord

Contusion. This is a very common form of injury It arises from blows, kicks squeezes and the like, and is always associated with immediate pain of a most sickening and intense character which is not only experienced in the testis, but also radiates along the cord towards the loins, back and down the front of the thigh. Severe shock often accompanies the pain. The undescended testis, unless abdominal in position is more exposed to trauma than the fully descended organ A well-marked traumatic orchitis often follows which may in turn cause atrophy of the organ although the same condition sometimes occurs without much evidence of inflammation as a result of hæmatocele or of thrombosis and occlusion of the spermatic vessels.

Treatment The patient should be kept lying down with the scrotum well raised and fomentations or an icebag applied. Clots should be turned out of very large hæmatoceles to prevent atrophy of the testis later

Penetrating Wounds or Punctures. These are uncommon except as a result of surgical treatment *e g* tapping a hydrocele. A certain amount of hæmorrhage usually follows, while the immediate lesion is associated with severe testicular pain If the wound becomes infected the tubules are likely to protrude and a hernia testis may result All that is ordinarily required is to purify the parts and allow them to heal sutures should not be inserted into the tunica albuginea if there is any doubt as to the wound being infected As much of the testis should always be preserved as possible, even when its viability is doubtful

Hæmatocele A localized collection of blood in the tunica vaginalis or cord a common result of injuries is called a hæmatocele

Hæmatocele of the Tunica Vaginalis This arises from trauma such as a sudden blow or severe strain. It occasionally follows the tapping of a hydrocele if a superficial vessel has been ruptured or punctured or if the body of the testis has been wounded. It also occurs more or less spontaneously in some cases of malignant disease. The history generally given is that the patient was seized with a sudden sickening pain in the testicle, which became quickly enlarged without any evidence of inflammation blood is extravasated at the same time into the scrotum the integument becoming discoloured in a few days (Fig 52.1) At first the swelling is smooth and fluctuating, exactly resembling a hydrocele except in the absence of translucency but owing to a deposit of fibrin on the walls, it soon becomes hard and firm closely simulating a solid tumour In slight cases the blood is entirely absorbed, but when the effusion is considerable the clot is likely to persist On laying open such a swelling the testis is usually found in a healthy state, but the enlarged tunica is occupied by blood-stained fluid, surrounded by a mass of fibrinous coagulum part of which is deposited in laminæ upon the walls, and part remains as shreddy masses projecting into its lumen. In very chronic cases the walls of the tunica become thick and indurated and may even undergo calcareous changes. Suppuration

is sometimes met with as a result of auto-infection. The diagnosis of a hæmatocele in the earlier stages is easily made but when it has solidified it can only be suspected by the history and by the exclusion of other sources of enlargement an exploratory incision is often necessary to settle the diagnosis and exclude malignancy

When the patient is seen soon after the injury he must be kept at rest the parts elevated and evaporating lotions applied if the effusion is large it should be evacuated. In more chronic cases it may be necessary to lay the cavity open and remove its contents, but if the tunica has become thick and indurated and the testis atrophied, removal may be advisable.

Hæmatocele of the Cord This is rarely seen A swelling of considerable size rapidly forms, extending along the cord from the inguinal region to the scrotum but the testis remains free and uninvolved Such a condition may be mistaken for an omental hernia but the tumour is more uniform in consistence, more rounded in outline, irreducible and without impulse the history of the injury will assist the surgeon in making a correct diagnosis



FIG. 52 1 HÆMATOCELE OF THE LEFT TUNICA VAGINALIS.

In the early stages this consists in the application of evaporating lotions and later if the blood-clot is not absorbed the cavity may be laid open and the clot removed.

Hernia Testis. This term is applied to a protrusion of the gland more or less infiltrated with granulation tissue, through an opening in the tunica albuginea and skin of the scrotum. It arises from various causes, such as a septic penetrating wound of the testis, acute suppurative orchitis or from a chronic abscess, whether simple or tuberculous in nature It is rarely produced by the breaking down of a gumma, owing to the extensive infiltra tion of the organ with fibrocicatricial tissue, and necessarily it is never caused by suppuration in the epididymis. It is always preceded by a condition of increased pressure within the tunica albuginea, and consequently as soon as an aperture is formed in this membrane its natural elasticity allowing of its contraction forces a portion of its contents out of the opening this may even proceed to such an extent as to cause the whole of the substance of the gland to protrude, the tunica albuginea being prac tically turned inside out. A mass resembling granulation tissue is then seen to project through an opening in the scrotum it is often somewhat pedunculated or mushroom-like in shape, possibly overhanging the margins of the

skin. A considerable discharge of pus usually accompanies it. The condition must be distinguished from the fungating growth which occasionally results from malignant disease of the organ when the protrusion consists of tumour substance, with no trace of testicular tissue

Treatment This usually consists in extirpation of the organ especially when it is affected by long-standing infection In simple cases healing of the wound may be obtained by keeping the part aseptic, and applying pressure by means of a pad of gauze. In other cases it may be possible to separate the protruding mass from the surrounding skin, and after paring the edges of the wound to bring them together by sutures, and thus bury the gland substance, which, however remains projecting from the opening in the tunica albuginea. Such proceedings are seldom very satisfactory

Orchidectomy Orchidectomy is required for many different conditions, *e.g* for injury malposition, tuberculous disease, old-standing hæmatoceles, and simple or malignant tumours The operation is conducted as follows

The pubes and perineum having been previously shaved and cleansed, the surgeon, standing on the same side of the patient as the organ to be removed, makes an incision down to the testis If large and adherent to the scrotal tissues, the incision must necessarily involve the scrotum, but if the testis can be displaced upwards it can be confined to the inguinal region. Scrotal incisions appear to heal well, however and have many advocates. In cases of tuberculous or malignant disease, the inguinal canal must be laid open so as to expose the internal ring. The testis or tumour is enucleated from its surroundings and the cord isolated and divided as high as possible, after transfixing and securely ligaturing it. Some surgeons prefer to separate the tissues of the cord and to take them up individually but this is a matter of little importance. The stump should not be allowed to slip back into the canal until all bleeding has completely stopped Bleeding-points in the scrotum are now secured by ligature, and these may be numerous the wound is closed by sutures, a drainage-tube being inserted in the scrotum through a separate stab

Subcapsular Orchidectomy This consists of removal of all parenchyma of testis and retention of the epididymis and tunica It is carried out in carcinoma of the prostate as, from a psychological point of view it is preferable to the more radical bilateral orchidectomy or castration

Inflammatory Affections

Inflammatory affections may be chiefly confined at their onset either to the testis or to the epididymis In the former case the term orchitis is applied to it, in the latter epididymitis as the case progresses both portions are involved in the process, either condition may be acute or chronic.

Acute Orchitis. This most frequently results as a direct extension of acute epididymitis it may also follow mumps typhoid or other fevers In mumps it may precede the parotid lesion or may even occur without it

The testis becomes considerably enlarged, exceedingly painful and tender to the touch. The shape of the organ is more or less globular (Fig 523) and the pain is of a peculiarly sickening character extending upwards along the course of the cord towards the back and loins. The scrotal integuments become red and infiltrated and owing to the acuteness of the process more or less adherent to the coverings of the gland A plastic or serous effusion

into the tunica vaginalis is sometimes present giving rise to what is known as an acute hydrocele. Some constitutional disturbance accompanies the process the temperature being elevated two or three degrees, and vomiting and constipation may occur It is unusual for suppuration to ensue but an abscess occasionally forms and then after the pus has been let out, a hernia of the testis may follow Atrophy is a more common sequel especially in adults, being caused by constriction of the vessels and tubules owing to organization of the inflammatory exudate. Bilateral atrophy after mumps may cause sterility

Acute Epididymitis. This is almost always due to the extension of an inflammatory process from the urethra the usual cause being gonorrhœa it

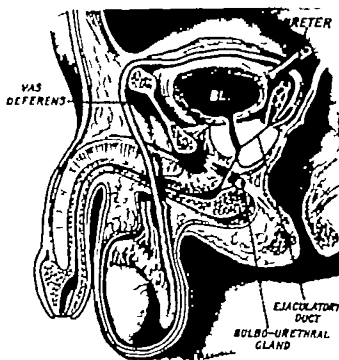


FIG. 52 2. THE ANATOMICAL COURSE OF THE VAS DEFERENS.

occasionally follows the passage of instruments or the lodgment of a calculus or it may be secondary to affections of the prostate if pyococci are present. It is ushered in by pain in the inguinal region and perhaps in the hypogastrium along the course of the vas deferens, which soon extends to the scrotum. The organ becomes enlarged but its shape is that of an elongated oval, somewhat flattened laterally The epididymis is readily felt as a crescentic swelling, partially overlapping the organ in all directions and in its concavity the rounded outline of the anterior wall of the testis can usually be distinguished (Fig. 52 3), or the tunica vaginalis distended with fluid. The scrotum is red, œdematous and adherent to the testis, and the cord is infiltrated enlarged, and tender The same constitutional symptoms are met with as in orchitis. Suppuration is extremely rare in gonococcal and *Esch. coli* infections coccal lesions, on the other hand (especially *Staph aureus*) tend

to soften rapidly the resulting abscess usually pointing over the most prominent part of the globus minor If radical treatment is not promptly carried out the greater part of the scrotal skin will become involved in the inflammatory process and multiple discharging sinuses will rapidly form. Once established such a condition will become chronic the sinuses intermittently discharging pus, necrotic portions of testicle and spermatic tubules more or less indefinitely Hernia testis may occur in long-standing cases. Atrophy of the testis may result from non-suppurative lesions, the plastic

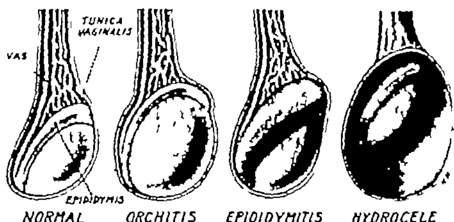


FIG. 52 3 DIAGRAMMATIC SECTIONS OF THE TESTICLE DEMONSTRATING VARIOUS PATHOLOGICAL CONDITIONS.

material exuded into the epididymis being organized into fibrocicatricial tissue and constricting the spermatic vessels an acute attack of double epididymitis may in this way render the individual sterile

Treatment In both these conditions, treatment in the acute stage consists in keeping the patient in bed with the scrotum supported on a small pillow Pain, if severe, may be eased by a hot bath and morphine Sulphonamides and antibiotics appear to have very little effect on inflammatory lesions of the testicle except those of gonococcal origin Orchidectomy should be carried out without delay whenever it is apparent that an abscess is forming. The criteria for operative treatment are extensive adherence of the scrotal skin and fluctuation. Both the testis and epididymis together with all adherent skin should be removed by means of a racket-shaped incision the spermatic cord being transfixed and divided at the external inguinal ring.

Subacute or chronic forms of inflammation are also met with affecting the testis or epididymis. The characteristic enlargement is readily detected associated with a certain amount of tenderness The condition is best treated by some form of support the administration of antibiotics such as tetracycline, 1 g daily for four days, will, in some cases assist in the resolution of the inflammation. Chronic orchitis is very similar to the enlargement produced by syphilis from which indeed it can only be distinguished by the Wassermann reaction being negative and the absence of a syphilitic history

Tuberculous Disease. This is most commonly seen in young adults with a tuberculous history but it also occurs in otherwise healthy individuals

It is always a secondary manifestation the primary infection occurring in the respiratory or gastro-intestinal tract The path of spread from primary lesions to epididymis is rarely directly by the blood stream but more often indirectly *via* the kidneys, prostate and seminal vesicles.

Pathological Anatomy The process originates in the connective tissue of the epididymis and runs its usual course, at first consisting merely of a deposit of miliary elements around the vessels which by their coalescence and caseation lead to the formation of cheesy masses, at a later stage giving rise to abscesses. It may be limited to any one part of the epididymis (most often the globus minor) or may widely infiltrate its substance causing a general enlargement (Fig. 52 4) In the latter case it tends to spread early either into the body of the testis or along the vas deferens The corpus Highmorianum becomes first involved by a similar deposit, and finally the intertubular connective tissue of the gland This is always associated with overgrowth of the epithelium in the tubuli seminiferi the cells after a time

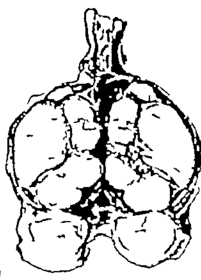


FIG 52 4 TUBERCULOUS DISEASE OF TESTIS, MAINLY INVOLVING THE EPIDIDYMIS AND CORD. (*King's College Hospital Museum.*)

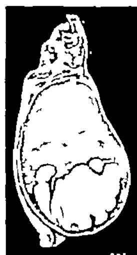


FIG. 52 5 GUMMA OF THE TESTIS. (*Royal College of Surgeons Museum.*)

undergoing fatty degeneration, perhaps to such an extent that, on microscopic section, the normal appearance of the organ has entirely disappeared An abscess may form within it and find its way to the surface, by burrowing through the tunica albuginea the visceral and parietal layers of the tunica vaginalis having previously become adherent. After the pus has escaped, a hernia testis is likely to develop When the process involves the cord, the vas is mainly implicated, becoming thickened and beaded the other structures of the cord being only little affected. Associated lesions of the prostate and seminal vesicles will be found in about 90 per cent. and urinary tuberculosis will be present (or will be confirmed subsequently) in about 50 per cent.

Clinical Signs The disease is generally unilateral, although the other side often becomes involved at a somewhat later date Its onset may be

abrupt or gradual in the former case the attack simulates an acute non-specific epididymitis-orchitis, but at the end of a few weeks, although the pain subsides, the swelling persists, being followed by the development of abscesses containing cheesy pus. In the more chronic cases, one or more firm and indurated nodules, which are free from tenderness, are felt in the epididymis, but more often the whole of this structure is found to be enlarged and thickened, forming a painless crescentic swelling, surrounding the posterior half of the body of the testis, from which it is usually separated by a deep groove or sulcus. The epididymis is nodular and craggy to the feel and may be of unequal consistence areas of softening being interposed between portions which are distinctly hard. The vas is early thickened while the other structures of the cord are little involved the thickening is more or less nodular and feels beaded. The body of the testis may be involved and enlarged the line of demarcation between it and the epididymis becoming indistinct Testicular sensation remains as long as any normal glandular tissue exists and effusion into the tunica vaginalis is not usual. When suppuration occurs, the pain increases, especially if the abscess is in the substance of the organ. As it finds its way to the surface, the skin which becomes adherent to the testis, is red and congested Gradually fluctuation manifests itself and the escape of the pus may be followed by a hernia testis. An abscess forming in connection with the epididymis is less painful and may attain considerable dimensions before it bursts it never gives rise to a hernia testis. Associated lesions of the prostate and seminal vesicles cause no characteristic symptoms and are only detected on rectal examination when however the base of the bladder and posterior urethra are affected considerable dysuria and irritability of the bladder are induced

It must be remembered that a tuberculous epididymis may be the only outward and visible sign of extensive, though symptomless genital or urinary tuberculosis For this reason a meticulous investigation of the entire urogenital tract must be undertaken in every case of this nature.

The differential diagnosis is discussed on p. 1332.

Treatment If seen in the early stage, when the disease is limited, the administration of anti-tuberculous drugs (streptomycin, PAS and isoniazid) for some months may result in complete resolution of the disease Sanatorium treatment is also of advantage, especially in more advanced cases. Surgery is only used as an adjunct to chemotherapy, for example to remove dead or caseous material and excise sinuses, or for patients who come late to chemotherapy or do not respond well to it.

When the whole epididymis is enlarged and solid and the body of the testis more or less normal, epididymectomy will usually suffice. In this procedure the tuberculous mass is freed from the body of the organ, the spermatic vessels lying on the inner side are carefully guarded, and the vas is dissected out and cleared as high as possible. The presence of an abscess or sinus is no contra indication since it merely involves a somewhat freer removal of scrotal integument. Should foci exist in the body of the testis, they are likely to respond to chemotherapy In this way the internal secretory function of the gland can be retained, although its use as a generative organ may be lost. Even if the vas is thickened at the external abdominal ring or the vesiculæ enlarged, it need not deter the surgeon from operating, since Nature, helped by anti-tuberculous drugs and constitutional measures, will often deal effectively with what is left.

Removal is reserved for cases where the testis is disorganized and its value as a secreting gland totally destroyed The cord is also removed after division as high up as possible It is feasible though rarely necessary to remove the epididymis vas, and seminal vesicle through an inguinal incision the approach to the last-named being extraperitoneal.

Division of the vas of the unaffected side while the disease is still unilateral may act as a prophylactic against bilateral involvement. As it will lead to sterility it should be done only with the patient s consent.

Syphilitic Disease The testicle may become affected either in the late secondary or in the tertiary stage most commonly it results from the acquired variety but occasionally is met with in the inherited It is rarely seen to-day in Britain.

Secondary Syphilitic Epididymitis This unusual condition occurs as a chronic enlargement of the epididymis, associated perhaps with a hydrocele about six to twelve months after infection The case is very similar to a simple chronic epididymitis but the nodular thickening mainly involves the globus major and is usually symmetrical It quickly disappears on the commencement of treatment.

Tertiary Syphilitic Orchitis This is observed at a much later period of the disease even twenty or thirty years after infection It may be bilateral Pathologically it resembles the majority of tertiary manifestations in consisting of a diffuse infiltration accompanied by overgrowth of the connective tissue. If the process affects the whole organ uniformly syphilitic sarcocele or sclerosis of the testis results if it is more localized in its distribution, the gummatous variety is said to be present. The former affection is much more common than the latter Sarcocele is the name given to any solid swelling of the testis.

In tertiary syphilitic sarcocele, the body of the testis is primarily involved and becomes evenly enlarged and stony hard It is globular in outline frequently accompanied by a hydrocele, and the normal testicular sensation early disappears. The same process occasionally extends to the epididymis and cord. Suppuration is exceedingly rare. On section the characteristic appearance of a testicle has entirely vanished the tunica albuginea is much thickened, and extending from it through the substance of the organ are bands of connective tissue representing the normal septa in severe degrees the gland substance is almost completely destroyed.

In the gummatous variety a similar condition involves the greater part of the organ but one or more gummatous foci are also present (Fig. 52 5). On section they appear as yellowish-white masses, fairly well defined and since the central portions are non-vascular they undergo the usual degenerative changes becoming soft and diffluent. If the gumma comes to the surface the skin may give way and a deep syphilitic ulcer with a sloughy base like wet wash-leather results. Hernia testis very rarely follows such an occurrence. The clinical features of the gummatous variety are at first similar to those of the former but after a time one portion of the organ becomes prominent and painful, and as this increases in size the central parts become soft fluctuating and finally yield, giving exit to the characteristic gummy contents Under suitable treatment the swelling in each of these varieties may disappear entirely leaving the testis either of normal size or atrophied but, as in tuberculous disease, its functional utility if not entirely destroyed is probably impaired considerably

Treatment consists in the administration of penicillin in full doses. Potassium iodide by mouth assists resolution of the swellings, while the hydrocele may be tapped and the organ strapped or supported by a suspensory bandage

Tumours of the Testis

These are invariably malignant. Most of these tumours can be classified under two main headings, seminomata and teratomata. A few authorities believe that all testicular tumours are teratomatous but most maintain that seminomata are carcinomatous in nature and are derived from spermatogenic



FIG 52 6. TERATOMA OF THE TESTIS.
There only remains a small portion of normal testis at the lower pole (T)

cells or spermatocytes. A teratoma producing a testicular dermoid is very rare

Pathology of Tumours. *Seminoma* When the cut surface is inspected it presents a homogeneous yellowish white appearance except for areas of degeneration and hæmorrhage which are common there is some tendency to lobulation.

Histologically seminoma consists of closely packed rounded cells with large deeply-staining nuclei these bear a close resemblance to certain spermatogenic cells In the areas undergoing necrosis the nuclei of the tumour cells stain feebly or not at all

Teratoma. This is somewhat slower in growth, but less amenable to treatment, being radioresistant. The cut surface of the growth varies in many cases there may be numerous small cysts (fibrocystic disease), areas of cartilage and large cysts (Fig. 52.6) Histologically derivatives of all

three germinal layers may be found, thus muscle may also be seen and gland structures, while the nature of the predominating cell may resemble a sarcoma or a carcinoma

Chorionepithelioma In some cases a chorionepithelioma similar to that occurring in the uterus, may be found This type of tumour may give rise to the excretion of large amounts of œstrogen in the urine. In other forms of testicular tumour estimation of œstrogen in the urine is of less value, the amount excreted bearing no constant relationship to the nature of the tumour or its rate of growth

Tumours of the Spermatic Cord These are sometimes observed and can usually be distinguished from fluid swellings by their firmer consistence and non-translucency They are usually lipomata or other connective tissue tumours and are rarely malignant

Clinical History These tumours appear between twenty five and fifty years of age a blow often attracting the patient s attention to the swelling the part played by trauma as a cause is doubtful Sometimes the testis has gradually increased in size for two or three years and then rapid growth has ensued

The glandular elements of the testis are destroyed or compressed at the upper or lower poles of the swelling, and testicular sensation is usually absent. The swelling feels heavy to the examining hand, but diagnosis from a hæmatocele may be impossible without exploration Therefore all doubtful lumps must be explored.

Dissemination in the case of teratoma occurs typically by the blood-stream with involvement of the lungs. A seminoma usually spreads by the lymphatics to the lumbar and para-aortic lymph-nodes the spermatic cord and the abdomen must always be examined for lymphatic enlargement. Metastases may be found in any organ particularly the liver and brain. Spread to the spinal column may give rise to collapse of vertebræ and com pression of the spinal cord. If untreated the overlying skin becomes adherent, ulceration and fungation soon following.

Treatment. Orchidectomy with removal of the cord as far as the internal abdominal ring should be the immediate treatment. More radical operations with the object of removal of the lymphatics of the posterior abdominal wall and pre aortic lymph nodes are practised by some surgeons, but in the case of seminoma radiotherapy to the lymphatic drainage area in the abdomen greatly improves the prognosis Radiotherapy appears to be of less value in treating teratoma.

Hydrocele

Any collection of fluid, other than pus or blood in the neighbourhood of the testis or cord is termed a hydrocele The fluid usually consists of serum, but in some forms spermatozoa are also present, and in rare cases it may consist of chyle or a similar milky fluid (chylous hydrocele) Two chief varieties are described according to whether the testis or the cord is involved.

Hydrocele of the Testis

In this condition the fluid is contained in the tunica vaginalis (vaginal hydrocele) or exists as a circumscribed swelling in its neighbourhood (encysted hydrocele)

Radical treatment consists in injection of the cavity or excision of the lining membrane

Injection is often painful and the results are variable Sodium morrhuate is the favourite reagent.

Open operation is now generally adopted, and is particularly recommended in large and chronic cases. The hydrocele is cut down on through an incision in the upper part of the scrotum, and the tunica vaginalis isolated from the superjacent structures. The cavity is opened and the parietal portion of the tunica snipped away with scissors close to the testis. A number of vessels will need to be ligatured a drainage tube is inserted

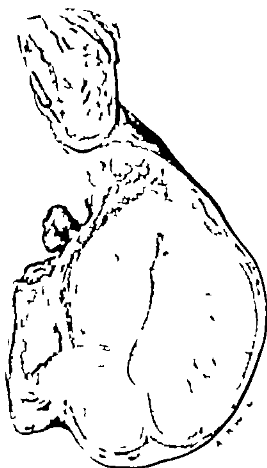


Fig. 52 9 Large Spermatocele removed at Operation.

and the wound closed in the ordinary way The results of this practice are most satisfactory When the sac is not too large and the tunica supple and uninfiltrated it often suffices to turn it inside out and stitch its edges to the back of the epididymis (Jaboulay s operation)

In infants hydrocele is common and may be but is not always of the communicating type The communication is sometimes very small so that reduction is impracticable, although on raising the legs the cavity slowly empties It is desirable to make certain as to this point before undertaking treatment If the sac communicates with the peritoneal cavity it may be treated as a hernia by operation. If no communication exists, many cases disappear spontaneously but after one year of age an open operation (incision with drainage or partial removal of the sac) will be required.

PLATE 12



[King's College Hospital Museum

TUBERCULOUS DISEASE OF THE EPIDIDYMIS.

The specimen shows disease spreading into the testis and a sinus communicating with the skin.

Encysted Hydrocele Encysted hydrocele occurs in two main forms according to whether it arises in connection with the epididymis or the body of the testis.

(1) *Encysted Hydrocele of the Epididymis or Spermatocele* This exists usually as a rounded globular swelling tense and elastic in consistence and translucent It is situated above the body of the testis and close to the head of the epididymis As a rule it does not attain a size greater than that of the body of the testis itself so that it may appear as if a double testicle is present the hydrocele is of course devoid of testicular sensation Less frequently it may attain considerable dimensions even projecting below and around the testicle which though enveloped by it is quite distinct from it. The fluid contained within these cysts is usually milky and opalescent in appearance owing to an admixture of semen under the microscope spermatozoa either living or dead can be demonstrated hence the term spermatocele The specific gravity is lower than that of ordinary hydrocele fluid and there is little albumen The origin of these cysts has given rise to much discussion They are of a very different nature from the ordinary vaginal hydrocele or even from the encysted hydrocele of the cord since the walls are not lined with endothelium but with cuboidal or columnar epithelium They are probably due either to a dilatation of one or more of the vasa efferentia testis or sometimes to distension of one of the vestigial structures (vasa aberrentia paradidymis hydatid of Morgagni) attached to the globus major of the epididymis

Treatment is conducted along the same lines as for vaginal hydrocele, i.e. by tapping as a palliative measure and injection or excision in order to establish a radical cure.

(2) *Encysted Hydrocele of the Body of the Testis* This is a condition rarely seen, consisting of a small collection of serous fluid beneath the visceral portion of the tunica vaginalis It is probably due to dilatation of lymphatic spaces, and has no clinical significance

Chylous Hydrocele. This term is applied to a distension of the tunica vaginalis with chylous fluid recognized by being milky in appearance, and under the microscope seen to consist of a fatty emulsion Several modes of origin have been suggested, the most probable being that this is a type of lymphangioma.

Hydrocele of the Cord

This occurs as already described in connection with the congenital and infantile varieties of vaginal hydrocele If limited to the cord it exists in one of two forms, the encysted or the diffuse.

Encysted Hydrocele of the Cord This arises from imperfect obliteration of the funicular process of peritoneum the patent portion becoming distended with fluid and giving rise to a cavity lined with epithelium It is usually detected as a rounded elastic swelling occupying the inguinal canal, moving freely up and down within it The upper border is sharply limited and in favourable cases translucency can be demonstrated. On fixing the testicle the cyst is no longer movable The fluid contained within it is identical in nature with that in a vaginal hydrocele In the female a similar condition arises from imperfect obliteration of the canal of Nuck giving rise to what is known as a hydrocele of the round ligament

Treatment This consists in removal of the fluid by tapping, or if a more radical proceeding is necessary by injection or excision.

Diffuse Hydrocele of the Cord. This condition is rarely seen. It results from a diffuse œdema of its cellular tissue and presents on examination a fusiform or sausage-shaped tumour which extends along the cord for a variable distance.

Varicocele

A varicose condition of the pampiniform plexus is very commonly met with in young men, but seldom in those of advanced age, except when it has become chronic, or is due to malignant disease of the kidney It usually occurs in individuals with a lax and pendulous scrotum and the fact that it sometimes develops in quite young boys suggests that there is some congenital condition associated with it, possibly absence or imperfect development of the cremaster muscle. It may also be caused by the pressure of a truss applied for the relief of a hernia. It is almost invariably on the left side, and the reasons given for this are as follows

(1) The left testis usually hangs lower than the right, hence the spermatic veins are longer and exposed to greater blood pressure.

(2) The left spermatic vein opens into the left renal vein at right angles and no valve is present at the orifice, while that on the right side opens obliquely into the vena cava and is valved.

(3) The presence of the sigmoid colon on the left side of the body and its distension by accumulated fæces as a result of constipation, may lead to pressure on the abdominal portion of the left spermatic vein

A varicocele is characterized by the presence of a soft, irregular swelling in the scrotum, which is somewhat pyramidal in shape, the main mass being below and slightly overlapping the testis and the apex above It consists of dilated and tortuous veins, the outlines of which can often be seen through the skin (Fig. 52.10). They impart a sensation to the finger which has been likened to a collection of living worms in a bag there is a distinct impulse on coughing. On assuming the recumbent posture the swelling almost disappears, owing to the vessels being emptied of their contained blood if pressure is subsequently applied over the external abdominal ring and the patient allowed to stand the tumour reappears, filling from below upwards. A sensation of weight and pain usually accompanies a varicocele and severe neuralgia of the testis may be induced It is often associated with imperfect development and sometimes with complete atrophy of the testicle. Phlebitis is liable to follow an injury and may lead to a spontaneous cure If one of the dilated veins is ruptured severe hæmorrhage ensues, causing a diffuse hæmatocele of the cord The condition tends to disappear spontaneously after middle-age.

Treatment Slight cases of varicocele are treated by supporting the testis and scrotum by means of a well-fitting suspensory bandage the patient is also instructed to bathe the parts with cold water night and morning. Surgical treatment by excision of the veins is an operation which has fallen into disuse. This is because the type of patient who complains of pain from a varicocele is likely to continue to complain no matter what treatment is instituted. In addition, if many of the veins are excised atrophy of the testis may follow or a hydrocele develop.

Operation is performed through an inguinal crease incision. The majority

of the veins constituting the pampiniform plexus are isolated as high and as low as possible. After ligatures have been applied above and below the intervening bundle of veins is excised and the two ligatures whose ends were left long, tied together This serves to reduce the number of veins and to elevate the low hanging testis. The spermatic artery must be carefully preserved Simple ligature of the internal spermatic veins at the internal inguinal ring will often relieve a varicocele more effectively than the removal of the pampiniform plexus and is becoming a more popular method in recent years.



FIG. 52 10. LARGE VARICOCELE IN A PATIENT AGED 35 YEARS.

Neuralgia of the Testis. This is characterized by the organ becoming exquisitely tender and painful, although apparently healthy It usually occurs in young adults of nervous temperament and may be associated with a varicocele The pain is usually paroxysmal in character and may be incapacitating.

Treatment must be directed mainly to the general health, physical and mental It is also advisable that a suspensory bandage should be worn. Orchidectomy is sometimes carried out as a last resort for intractable cases but the results may be disappointing owing to recurrence of pain at the site of the divided cord

Atrophy of the Testis and Sterility

Atrophy This may result from several causes

(1) It may be due to a congenital arrest of development, as met with in displacement or late descent

(2) It is most frequently the consequence of inflammatory affections, either of the body or epididymis. It occasionally follows the orchitis of mumps, especially in adults and is also due to syphilitic disease.

(3) It arises from impaired nutrition, as after the division of the supplying arteries in operations for varicocele or hernia, from compression of the cord by closing the inguinal canal too firmly in the operation for the radical cure of hernia, or as a late result of torsion of the testis or spermatic cord. It appears, however that division of the spermatic vessels in an adult, will not suffice to determine atrophy if the artery to the vas, with its accompany

ing veins and nerves is preserved intact. A similar accident in a child will, however suffice to prevent development of the organ

(4) Chronic congestion of the testis, as by varicocele, may induce atrophy If unilateral, it is of comparatively little importance but where both testes are affected, sterility is likely and the patient may develop an anxiety state

Sterility Sterility in the male is responsible for approximately 50 per cent. of all childless marriages. The diagnosis can be readily established by examination of several specimens of semen, preferably after a period of abstinence. In collecting a condom specimen the sheath should be washed before use to remove the spermicidal powder with which it is usually coated. A normal count should be approximately 100 000 000 sperms per ml with less than 20 per cent. abnormal forms. Normally 40 per cent should remain motile after eight hours. Sterility can be regarded as absolute where spermatozoa are persistently absent (azoospermia) but more often it is partial ("sub-fertility") and the ejaculate is found to contain insufficient numbers of healthy spermatozoa (oligospermia, necrospermia).

The ætiology may be constitutional (impaired state of general health), endocrine or local Local causes may affect spermatogenesis (atrophy of the testis from any cause, hypoplasia) or prevent the passage of spermatozoa from testis to ejaculate (imperfect development past inflammatory or degenerate changes involving the vas or epididymis).

Treatment This is directed to the cause if this can be ascertained. Gonadotrophic hormones and testosterone are of limited value in certain cases of subfertility

General Diagnosis of Scrotal Tumours

When a patient presents himself for examination with a swelling in the scrotum, the surgeon has to decide whether it is a hernia a hydrocele a hæmatocele a varicocele, or a solid enlargement of the testis and, if the latter of what nature. The first point to which attention is directed is the condition of the cord immediately below the external ring If this is of normal size and consistence hernia and diffuse hydrocele of the cord are thereby excluded, the existence of a rounded tense swelling, movable within the canal but becoming fixed on holding the testis, indicates that an encysted hydrocele of the cord is probably present. When, however the cord is more or less masked further examination speedily determines whether a hernia or a diffuse hydrocele or hæmatocele of the cord exists, since the former is often reducible, has an expansile impulse on coughing and is rounded or nodular in outline, while the latter are sausage-shaped, always reducible and may fluctuate.

When the swelling is purely scrotal inspection and manipulation will at once decide if it is a varicocele by its characteristic feel by its disappearance on lying down and filling again from below on standing up. If the swelling is rounded in outline, the next point to be determined is whether it is solid or fluid. If fluid it is probably a hydrocele or the early stage of a hæmatocele the translucency of the former and the sudden appearance and non-translucency of the latter should suffice to demonstrate their nature It is possible that the hydrocele is merely a secondary complication hence no final opinion should be given until it has been tapped, and the condition of the body of the testis investigated If however a solid mass exists in the

scrotum it is either a hæmatocele in its later stages or some form of enlargement of the testis whether inflammatory syphilitic tuberculous or neoplastic.

A hæmatocele is possibly recognized by its history and by there being a fluid centre to the swelling, surrounded by solidified tissue Chronic orchitis and syphilitic enlargement of the testis are so much alike as to render diagnosis always uncertain in the absence of a distinct syphilitic history but if the swelling is extremely hard with a smooth and regular outline without testicular sensation, limited to the body of the testis and accompanied by a hydrocele it is probably syphilitic.

Tuberculous disease on the other hand occurs more frequently in younger individuals than does the syphilitic variety the epididymis is usually first attacked becoming nodular the cord is early involved hydrocele is rare, suppuration is frequent, and the testicular sensation remains till the body of the testis is disorganized

Tumours always impart a distinct sense of weight to the hand quite different from that noticed in tuberculous or syphilitic disease If a tumour s present it is rounded slow in growth, and the cord is unaffected Highly nalignant tumours are characterized by rapid growth more severe pain, nd early involvement of the structures of the cord and of the aortic mphatic nodes. The enlargement of both testes is in favour of tubercle or philis rather than of malignant disease A certain small number of cases ll remain where in spite of every care the nature of the mass is still a matter of doubt in such the diagnosis cannot be established without an exploratory incision

While weighing carefully the local conditions due importance should be given to the general history and condition of the patient his age appearance, previous habits and illnesses, etc., and his reaction to the Wassermann test. At the same time an examination of the internal organs should be made to ascertain, as far as possible the existence or not of concurrent disease e.g tuberculous disease of the lungs seminal vesicles or kidneys, or secondary malignant deposits

THE SEMINAL VESICLES

Acute Vesiculitis. This is not often met with, but sometimes arises in association with prostatitis, as a complication of gonorrhœa, or it may follow a tied in catheter or intra urethral injection of infected material or strong antiseptics. It is characterized by a deep-seated pain in the perineum together with irritability of the neck of the bladder and increased frequency of micturition. Defæcation becomes painful and on examination of the rectum the vesiculæ can be felt enlarged and tender If suppuration ensues an abscess forms, which usually bursts into the rectum, or less commonly into the bladder or peritoneal cavity

In some cases it may be necessary to evacuate the pus, the vesicle being approached from the perineum as in perineal exposure of the prostate. Acute infection is liable to be followed by chronic vesiculitis sometimes with acute exacerbations.

Subacute or Chronic Vesiculitis. This is not uncommon, the latter condition being often associated with prostatitis, and may be a cause of

persistent gleet. Seminal emissions and priapism may be caused by it, and the enlarged organ can be felt through the rectum. A good deal of pain often referred to the back is experienced The treatment is the same as for chronic prostatitis although it is somewhat doubtful whether diathermy is of much use in these cases. Special forms of treatment such as dilatation of the stenosed ejaculatory ducts or vasotomy with injections of antiseptics are employed with variable results. In refractory cases vesiculectomy is sometimes undertaken.

Tuberculous Disease. Koch s bacillus often attacks the seminal vesicles and may be associated with similar disease of the prostate and base of the bladder Spread along the vas will give rise to tuberculous epididymitis in the great majority of cases. The organs can be felt enlarged and if suppuration occurs, the abscess may burst into the rectum or bladder or possibly into both, a rectovesical fistula being thereby developed Suppuration is, however very rare in tuberculous vesiculitis in most cases the lesion becomes surrounded by fibrous tissue and spontaneous cure takes place Almost the only indication for surgical intervention is suppuration associated with secondary infection The vesiculæ can be approached through a curved incision in the perineum with its convexity forwards, displacing the rectum backwards and the bladder and prostate forwards. When the vesiculæ have been exposed complete excision of the lesion should be attempted, otherwise the operation may be followed by persistent sinus or fistula formation.

THE SCROTUM

Injuries to the Scrotum. Contusion and blows give rise to ecchymosis, which may be so extensive as to warrant the term *hæmatoma scroti* which has been applied to it.

Incised wounds may affect the skin and subcutaneous tissues, or may lay open the tunica vaginalis with or without protrusion of the testicle All that is needed in such cases is to render the wound aseptic and deal with it on general principles. Considerable destruction of scrotal tissue may be repaired by transplanting flaps from the inguinal region or by grafting by Thiersch s method.

Cellulitis of the Scrotum. This most commonly results from extravasation of urine which is described in Chapter 51 It may occasionally arise from other causes and leads to great constitutional disturbance and often to considerable sloughing the testes may be exposed when the sloughs come away or may even be involved in the same process. As a general rule repair is very active in the scrotum.

Œdema of the Scrotum. This is usually due to heart failure or nephritis and is often associated with ascites. It may attain considerable dimensions Acute inflammatory œdema of the scrotum is a term sometimes applied to erysipelas affecting this region on account of the absence of the vivid red colour usually caused by that affection. Considerable œdema is always present, and gangrene of the skin may result. As soon as the gangrene becomes limited it should be excised, and the margins of the wound brought together by sutures, or allowed to heal by granulation.

Fistulæ and Sinuses. These are normally caused by the bursting of

periurethral abscesses or are found in connection with tuberculous or syphili tic disease of the testis

Elephantiasis. Enormous enlargement of the scrotal tissues is due to a combination of infection with *Filaria bancrofti* complicated by recurrent attacks of inflammation This is described in Chapter 41 Excision of the mass is necessary Lesser degrees of this condition are due to widespread removal of lymphatics (e.g bilateral block dissection of the groins)

Eczema of the Scrotum. This is a troublesome affection, giving rise to pruritus and great irritation It results from the presence of pediculi but the more chronic forms occur amongst workers in tar and paraffin and also in chimney-sweeps, being due to the constant irritation of the corrugated scrotal integument by dirty clothes It is associated with the presence of warty outgrowths and may undergo malignant change



FIG. 52 11 ECZEMA OF THE SCROTUM, SHOWING AN ASSOCIATED WARTY OUTGROWTH ON THE PENIS

Neoplasms. The original form of cancer to be ascribed to a particular occupation was "chimney-sweeps" cancer of the scrotum. More recently pitch-warts have been similarly found to occur among workers in tar pitch, etc.

Carcinoma Ulceration appears in a papilloma and this spreads super ficially or deeply The inguinal lymph nodes become infiltrated, though often after a long interval. Remote metastases are rare. Superficial X ray therapy is effective in curing the condition though the laxity of the scrotal skin lends itself to wide excision. If the regional nodes are involved, block dissection should be performed. In more advanced cases removal of the testis may be required.

Melanoma This is rare in the scrotum but has the usual tendencies of the disease—viz. to involve lymph nodes at an early stage and disseminate widely Treatment must be by radical excision irradiation is seldom effective.

Chapter 53

THE FEMALE GENITAL ORGANS

Introduction

In this chapter no attempt is made to present the whole subject of gynæcology which extends into the domain of medicine as well as that of surgery In few branches of medicine does the marital, obstetric and social background of the patient affect the assessment of symptoms so much. In treatment, obstetric and endocrine problems often arise and cannot be separated from the purely surgical aspect of the subject. All that will be attempted is a concise presentation of the pathology and treatment of the more important surgical diseases of the female genital organs, especial regard being paid to those that may be encountered by the general surgeon.

Congenital Malformations

Malformations of the Ovary Congenital absence of the ovary is so rare as to be almost unknown but the ovary may be arrested at any point along its line of normal descent from the lumbar region and an ovary may sometimes be found in the sac of a congenital or acquired hernia. Turner's syndrome (gonadal dysgenesis) is a rare condition, sometimes associated with other anomalies such as webbing of the neck, in which the true (nuclear) sex is male, but the body form is female The gonads are undifferentiated and functionless.

Malformations of the Uterus. There may be varying degrees of uterine hypoplasia ranging from slight underdevelopment to the *uterus rudimentarius* in which the uterus is only represented by a small fibrous nodule Amenorrhœa and sterility occur in severe cases.

Another class of uterine malformations is due to defective fusion of the Müllerian ducts, and the defects vary from the presence of two complete uteri (*uterus didelphys*) to a depression in the fundus which denotes the slightest degree of imperfect fusion. An important form is the *uterus bicornis with a rudimentary horn*, in which the latter is, as a rule, attached to a single cervix by a band of fibromuscular tissue. If pregnancy occurs in such a horn it will rupture and give rise to symptoms resembling those of extra uterine pregnancy (see p 1354).

Malformations of the Vagina. In all the above malformations the vagina may be double. *Absence of the vagina* occasionally occurs In which case the uterus is usually rudimentary To enable normal intercourse to take place it is a relatively simple procedure to dissect a cavity in the vaginal site and to line this with a Thiersch skin graft held on an appropriate mould.

Localized atresia is a more common defect—the so-called *imperforate hymen*—though the obstructing membrane is usually just above the hymen After the establishment of menstruation, the menstrual fluid cannot escape and distends the vagina, to give rise to the condition known as *hæmatocolpos*

The menses fail to appear there is colicky lower abdominal pain and some times retention of urine due to upward displacement of the bladder by the dilated vagina The treatment is to incise the membrane and liberate the accumulated tarry fluid

Injuries of the Female Genitalia

Injuries to the External Genitalia. Apart from those due to parturition injuries result from kicks blows or such an event as a fall astride some object The hymen and vaginal orifice may be severely torn at coitus There is a rich local blood-supply especially during pregnancy and slight injury may cause severe hæmorrhage either external, or subcutaneous in the form of a large hæmatoma If a hæmatoma forms the labium becomes greatly swollen and discoloured firm to the touch, and extremely tender and painful suppuration may follow

Treatment Open hæmorrhage is controlled by ligature or packing, as indicated by the nature of the wound Wounds are sutured if possible especially any laceration of the rectovaginal septum, but if there is a large hæmatoma this must be incised to turn out the clot and then packed. In such cases primary suture is almost invariably followed by suppuration and should not be attempted

Injuries following Childbirth. Slight injuries in the form of laceration of the vagina or perineum are extremely common, and as a rule heal well without complications after immediate suture Severe injuries are nowadays less common than in the past, thanks to the improved standard of obstetric practice. The injuries to be considered here mostly represent the failures of the primary healing process

Lacerations of the Perineum These are the commonest injuries of the birth canal, and are divided into complete and incomplete varieties. In complete laceration the sphincter of the anus is torn through, and the rectum itself may be laid open for a considerable distance The symptoms of an unhealed incomplete laceration are not very pronounced, although there is a predisposition to vaginal prolapse In a complete tear flatus and fæcal matter escape involuntarily especially if the motions are loose.

Perineal lacerations are repaired by the operation of *perineorrhaphy* After excising any superficial scar tissue, the vaginal mucous membrane, the torn perineal body and the perineal skin are re-united by sutures so as to restore the parts to their original relationships In complete lacerations the important steps of the operation are the freshening and suturing of the edges of the tear in the rectum and the union of the torn ends of the sphincter ani.

Lacerations of the Cervix With chronic cervicitis these give rise to mucopurulent vaginal discharge Treatment consists of repair of the laceration by the plastic operation of *trachelorrhaphy* or of amputation of the cervix.

Vesicovaginal Fistulæ These are repaired by an operation, of which he principle is to excise the edges of the fistula and then to suture the penings in the bladder and vagina in separate layers.

Rectovaginal Fistulæ These are usually associated with complete laceration of the perineum and are dealt with by the operation described above for that injury especial attention being paid to freshening and uniting the edges of the torn rectal wall.

Displacements of the Uterus and Vaginal Walls

Prolapse The various forms of downward displacement of the uterus and vagina are grouped together under the comprehensive term prolapse *Prolapse is due to weakening or damage to the normal supports of the uterus and vagina* The uterus and the vaginal vault are supported by the transverse pelvic (cardinal) and uterosacral ligaments, which are part of the visceral pelvic fascia. The posterior vaginal wall is supported by the perineal body into which the levator ani muscles are inserted and since the anterior vaginal wall rests upon the posterior vaginal wall the levator ani muscles also indirectly support the anterior wall

Prolapse is nearly always seen in parous women in whom these structures have been torn or overstretched during parturition. The rare cases that occur in nulliparæ are usually seen in elderly women in whom the supports are atrophic.

Types of Prolapse Clinically five types of prolapse may be observed

(1) *Cystocele* The vaginal orifice is wide and when the patient strains down the anterior wall bulges outside the orifice as a smooth round swelling.

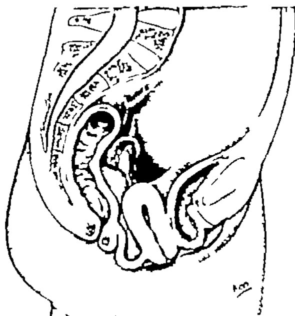


FIG. 53 1 PROCIDENTIA.

The bulging pouch of the vagina contains part of the bladder as may be demonstrated by passing a bladder sound There may be no accompanying descent of the uterus.

(2) *Classical Uterine Descent* This is the commonest form and three stages are observed. In the first stage, the anterior wall bulges as in cystocele and at the same time the uterus descends and becomes retroverted In a later stage the anterior wall is completely everted the cervix appears at the vaginal orifice and about half the posterior vaginal wall is inverted from above downwards. The final stage is known as *procidentia* the vagina is turned completely inside out, and hangs outside the vulva with the cervix at the apex of the protruding mass within which lie the uterus bladder and rectovaginal peritoneal pouch

(3) *Rectocele* When the patient strains the posterior vaginal wall bulges outside the vaginal orifice in the form of a swelling which contains a pouch of rectum as is easily demonstrated by rectal examination the anterior wall and uterus maintain their normal position

(4) *Inversion of the Vagina from Above Downwards* When the patient strains the cervix appears outside the vaginal orifice the vaginal wall descends with the cervix the vagina being inverted from above downwards but there is no cystocele or rectocele

(5) *Enterocele* A hernia of the rectovaginal peritoneal pouch through the posterior fornix may occur usually in association with a rectocele or after vaginal hysterectomy but occasionally as a congenital defect.

All these types of prolapse may occur singly or in combination thus rectocele and cystocele are often combined and either or both may be associated with classical prolapse or with inversion of the vagina from above downwards.

Symptoms A patient with prolapse complains of dragging discomfort and "something coming down" Although patients with prolapse often complain of backache this is usually due to some other cause. In cases of cystocele there may be frequency or stress incontinence (see below) and with procidentia there is sometimes difficulty in micturition unless the mass is pushed up In long-standing cases there may be ulceration and infection of the prolapsed mucosa

Treatment Prolapse may be treated by inserting a ring pessary This does not cure the condition but merely affords a temporary support in the manner that a truss controls a hernia. A pessary acts as a foreign body in the vagina causing discharge, requiring to be changed at regular intervals, and condemning the patient to much inconvenience for the rest of her life. Unless the age or general condition of the patient forbid it, all forms of prolapse should be treated operatively which entails very small risk and is almost invariably successful.

The operation usually performed is a combined vaginal and perineal plastic operation, which aims at tightening the relaxed fascial supports, at reducing the area of stretched vaginal walls, and at building up the perineum. For cystocele the operation of *anterior colporrhaphy* is performed, for rectocele *posterior colpoperineorrhaphy* and for the combined forms of prolapse both operations are combined with amputation of the cervix or vaginal hysterectomy which allows full exposure of the cardinal ligaments so that they can be tightened

Retroversion. The normal position of the uterus is one of anteversion and anteflexion, the long axis of the uterus inclining forwards, with an anterior obtuse angle between the cervix and body In retroversion the whole uterus is rotated on a transverse axis passing through the cervix, so that the long axis is inclined backwards instead of forwards. *Retroversion is a physical sign not a disease* It is estimated to be present in 20 per cent. of healthy women in whom it causes no symptoms, and requires no treatment Retroversion may be acquired for the first time during the puerperium, when the lax pelvic supports allow the heavy uterus to fall back. In other cases retroversion is the result of pelvic inflammation, the uterus being held backwards by adhesions, or it may arise when a pelvic tumour displaces the uterus. In cases of prolapse the uterus becomes retroverted.

Diagnosis On vaginal examination the cervix is found pointing down-

wards and forwards, and the body of the uterus is felt through the posterior fornix on bimanual examination the diagnosis is confirmed by failure to palpate the body of the uterus through the anterior fornix.

Symptoms A healthy retroverted uterus seldom causes symptoms, but in complicated retroversion treatment may be necessary for the cause (*e g* prolapse or salpingitis). During pregnancy a retroverted uterus usually rises up into the abdomen uneventfully but in a few cases the retroverted gravid uterus may become incarcerated in the pelvis and cause retention of urine

Treatment In cases in which retroversion causes symptoms, the uterus may be replaced by manipulation and kept in the normal forward position with a Hodge pessary A pessary only acts as a temporary support, and a permanent cure is obtained by the operation of *ventrosuspension* in which the round ligaments are shortened, so as to hold the uterus forward.

Stress Incontinence. After childbearing the sphincter mechanism of the bladder neck may be damaged, so that the patient has slight incontinence whenever the intra-abdominal pressure is raised *e.g* on coughing. If colporrhaphy does not relieve this symptom a sling of fascia lata may be used to elevate and support the urethrovesical junction.

Infections of the Lower Genital Tract

Vulvitis. Inflammation of the vulva as a whole may be due to any irritating vaginal discharge, to uncleanliness, and occurs in diabetes owing to infection with *Monilia (Candida) albicans* The vulva is red and swollen, and there is burning or itching. Treatment consists of removal of the cause, keeping the vulva cleansed with a mild antiseptic lotion followed by drying and painting with an antiseptic such as 1 per cent. gentian violet. Monilial infection responds well to nystatin

Gangrenous vulvitis (noma pudendi) is a rare but dangerous event in debilitated children. Penicillin is given, and infected tissue radically excised.

Vulval Ulceration. This may be due to the causes just mentioned, and also to chancre, soft sore, lymphogranuloma venereum tuberculosis (very rare) or carcinoma.

Vulval Leukoplakia. More than one condition has been included under this heading. Most cases in which the skin of the vulva appear white and thickened are due to *lichenification* a chronic inflammatory process which is reversible. It is due to irritation of the skin by vaginal discharge persistent scratching, or allergic reaction of the skin The cause must be sought and removed and a bland ointment such as 1 per cent phenol in zinc cream applied. 2 per cent. hydrocortisone ointment may be used

True leukoplakia This is a dangerous and irreversible condition, which may be followed by epithelioma The cells of the basal layer of the epidermis proliferate irregularly and keratinization of the superficial cells is abnormal. Biopsy is essential of any white patch which persists in spite of the local treatment described above If abnormal proliferative changes are found the affected skin is excised.

Bartholinitis. Infection of the vestibular glands may be due to gonorrhœa but is more often due to non-venereal infection A painful red swelling appears beneath the posterior part of the labium Local heat is applied, with chemotherapy but suppuration usually occurs and incision is required If the condition recurs the whole gland is excised A *Bartholin*

cyst occurs if the duct becomes blocked when a translucent swelling appears. Such a cyst should be excised taking care to remove the whole of the gland

Vaginal Discharge Patients with discharge seldom consult a general surgeon so that these cases will not be fully described The source of discharge may not be the vagina itself but the cervix, and many cases of *chronic cervicitis* are treated by diathermy cauterization Vaginitis may be due to *trichomonads* (flagellate protozoa) *Candida* or infection around a retained foreign body *Senile vaginitis* is due to ascending mixed infection, which may occur when the normal vaginal acid secretion ceases after the menopause Such infection may reach the uterus to cause *senile endometritis* and sometimes pus may accumulate in the uterus (*pyometra*)

Infections of the Uterus, Tubes and Ovaries

Gonorrhea. In the female the initial sites of gonococcal infection are the urethra, cervix and vestibular (Bartholin) glands the vagina is not infected except in children Acute gonococcal infection may spread upwards to the uterus and tubes and reach the pelvic peritoneum Infection does not persist in the endometrium but tubal lesions often become chronic.

Acute Gonococcal Salpingitis. The tube becomes acutely inflamed, and though resolution sometimes occurs more often the ends of the tube become



FIG. 53 2. CHRONIC SALPINGITIS.
Subtotal hysterectomy has been performed. Both tubes are distended with pus, and bound down by adhesions.

blocked by swelling and adherence of the mucosal folds, and the tube then becomes distended with pus Pelvic peritonitis occurs but practically always becomes localized, though a pelvic abscess may form.

Symptoms There is fever (102°) and lower abdominal pain when the peritoneum is involved. There is tenderness and guarding, and on vaginal examination there is such extreme tenderness in both fornices that precise definition of the adnexæ is impossible, though ill-defined masses consisting of the matted tubes and adjacent structures may be felt. There is usually purulent urethral and cervical discharge, in which gonococci may be found. After a few days a pelvic abscess may form, which may point rectally

Treatment Nearly all acute cases respond to conservative treatment.

The patient is kept in bed and a course of penicillin is given. Sedatives and the application of heat to the abdomen will relieve pain If an abscess forms, or in the rare event of spreading peritonitis, operation is required

Chronic Gonococcal Salpingitis. Some acute cases do not completely resolve, but become chronic. The tube may become distended with pus (*pyosalpinx*) or with serous fluid (*hydrosalpinx*) or may become blocked and matted to the ovary and adjacent structures by adhesions (*chronic interstitial salpingo-oöphoritis*)

Symptoms All these lesions result in chronic ill-health, with pelvic pain dysmenorrhœa menorrhagia and sterility Recurrent acute exacerbations may occur On pelvic examination fixed bilateral tender swellings are felt, lying postero-lateral to the uterus which is often fixed in retroversion.

Treatment During an acute exacerbation the case is treated as described above for acute salpingitis but if there are recurrent attacks or persistent symptoms that do not respond to conservative measures, or if there is a large pelvic mass, then surgical treatment is advised. Chronic pyosalpinx is treated by removing the affected tube or tubes by the abdominal route When the disease is bilateral the ovaries and cervix are probably infected as well and a *radical operation including complete removal of the tubes and ovaries* and of the uterus, is usually the best operation In non-suppurative cases less radical procedures may be possible, and the uterus and ovaries may be conserved. A pelvic abscess *is best drained through the posterior fornix (posterior colpotomy)*. Operations for chronic pelvic infection may sometimes be extremely difficult because of the widespread adhesions.

Postpartum and Postabortum Infections. These are not the responsibility of the general surgeon in the acute stages, which are not described here The initial infection, especially if streptococcal, is widespread, involving pelvic cellular tissue and peritoneum as well as the uterus, tubes and ovaries but infection seldom persists except in the cervix or tubes *Puerperal salpingitis* is often only diagnosed when a widespread infection recedes. It otherwise resembles gonococcal salpingitis, causing similar acute and chronic lesions.

Pelvic Cellulitis. This is usually due to puerperal infection and commonly makes its appearance in the second week after delivery There is fever and on vaginal examination a hard, thick diffuse swelling displacing and fixing the cervix, is felt. After several weeks the mass may gradually absorb but sometimes an abscess forms, which may point above the inguinal *ligament, or towards the rectum or other viscus*, or rarely into the thigh or buttock through one or other of the pelvic foramina Such an abscess should be drained by an incision above the inguinal ligament or through the posterior vaginal fornix.

Tuberculosis. *Infection of the female genital organs is probably carried* by the blood-stream from a distant focus. The most common lesion is chronic salpingitis, but the ovary and uterus may also be involved and tuberculous ascites may occur If the infection is widespread sanatorium treatment is advised (including treatment with streptomycin and PAS) but strictly localized lesions may be excised.

Neoplasms of the Vulva

Innocent Tumours. *Fibroma* and *lipoma* may occur They are easily excised *Papillomata* (condylomata acuminata) occur as multiple warty

proliferations in cases with profuse discharge The papillomata may require cauterization with the diathermy

Carcinoma of the Vulva. This is nearly always a squamous growth, but adenocarcinoma very rarely arises from the epithelium of the vestibular (Bartholin's) gland The commonest sites of origin are the labium majus and clitoris. Growth is usually rapid and lymphatic spread to the inguinal nodes occurs early In many cases the growth is preceded by *leukoplakia*

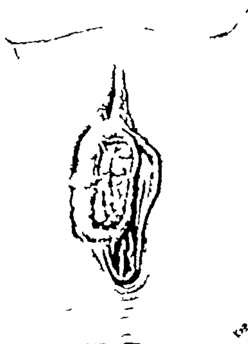


FIG. 53 3 CARCINOMA OF THE VULVA.

The first symptom is pruritus, and later there is blood-stained discharge from the ulcerated surface.

Treatment This consists of wide excision of the vulva, together with the inguinal nodes on both sides. The iliac nodes may also be removed by an extraperitoneal approach through each inguinal region.

Malignant Melanoma. This is very rare but highly malignant, metastasizing early

The Urethra

Urethral Caruncle. This common tumour appears at the posterior margin of the urethral orifice. It is usually about 0 5 cm. in diameter is excessively tender to touch, giving rise to pain on micturition or coitus. There may be slight bleeding. In some cases a urethral caruncle is composed of granulation tissue covered with squamous epithelium and results from a chronic inflammation of the terminal portion of the urethra in *other cases it appears to be an adenoma arising from urethral glands.* Urethral caruncles are treated by complete excision, which must include the subjacent area of mucous membrane.

Prolapse of the Urethral Mucosa. This may be confused with urethral

caruncle. *It may either arise acutely following* some straining effort, in which case the prolapsed mass may become strangulated, or more commonly the condition is chronic. Treatment consists of excising the prolapsed tissue, and neatly reforming the urethral orifice.

Carcinoma of the Urethra. Primary growth is very uncommon although secondary deposits from carcinoma of the cervix or corpus occur more frequently The growth may be treated by interstitial radium needling.

Uterine Fibroids

Fibromyoma. Uterine fibroids are among the commonest tumours found in the body and are found especially between the ages of thirty five and fifty They are benign solid tumours, composed of a mixture of unstriped muscle and fibrous tissue the relative proportions of which vary in different cases.

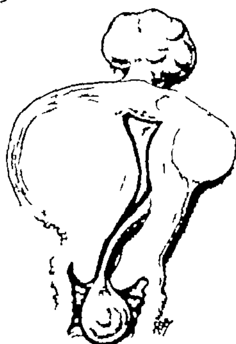


FIG 53 4 UTERINE FIBROMYOMATA. The fibroid on the left is interstitial that on the right is sessile and subperitoneal that at the top of the uterus is pedunculated and subperitoneal while a pedunculated subendometrial fibroid has been extended through the cervix.

Typically they are spherical in shape and can be shelled out of the wall of the uterus. They have a poor blood-supply and lie in a capsule formed by the compressed tissues of the uterine wall. Fibroids may be single or multiple, and vary in size from small seed-like structures to enormous tumours which may fill the abdominal cavity Ninety six per cent of fibroids occur in the body of the uterus and only 4 per cent in the cervix

According to the position which they occupy they are known as (a) interstitial when they are completely surrounded by the muscular tissue of the uterine wall (*b*) *subperitoneal* when they project outwardly being covered at their site of projection by the peritoneum and (*c*) *subendometrial when the part which lies next to the uterine cavity is covered by endometrium.*

Both subperitoneal and subendometrial tumours may become pedunculated pedunculated subendometrial tumours are termed fibroid polypi Tumours growing from the lateral wall of the uterus burrow between the layers of the broad ligament and if they grow to any size strip the peritoneum from the pelvic walls, and may even split apart the layers of the mesentery of the sigmoid

A subperitoneal pedunculated tumour may undergo *torsion* with consequent impairment of the blood-supply and necrosis Owing to their comparatively poor blood-supply all fibromyomata are subject to various *degenerative changes* *atrophy* may occur after the menopause *hyaline degeneration* results in areas of softening in *fatty degeneration* scattered deposits of fat are found throughout the tumour in *calcareous degeneration* lime salts are deposited in the tumour In *cystic degeneration* irregular cavities filled with viscid fluid arise from liquefaction of areas of hyaline degeneration. *Red degeneration* (necrobiosis) is the result of thrombosis of the capsular vessels, and is especially liable to occur during pregnancy On section a necrobiotic fibroid presents a striking alteration in colour varying from pink to deep red The clinical manifestations are pain and tenderness of the tumour and a rise of temperature. These symptoms usually subside spontaneously *Septic infection* of fibromyomata sometimes occurs after labour from extension of infection from the uterine cavity *Sarcomatous change* occurs in less than 1 per cent. of all fibroids it leads to rapid growth, but is often only discovered after removal of a supposedly innocent tumour Fibroids do not undergo carcinomatous change, though carcinoma of the body of the uterus may occur in association with fibroids.

Symptoms The symptoms of fibroids vary much in different cases Even when of large size they may cause no symptoms. In other cases there may be a great variety of symptoms and their occurrence depends upon (*a*) The extent to which the tumours approach, project into or enlarge the uterine cavity (*b*) Whether the tumours grow in such positions as to cause mechanical effects on the surrounding organs. (*c*) The occurrence of certain forms of degeneration. (*d*) Interference with the reproductive function. (*e*) Rare complications such as torsion or infection of the tumour

The commonest symptom is menorrhagia, or an increased loss at the menstrual periods. The commonest mechanical effect is retention of urine which occurs with cervical or broad ligament fibroids.

Treatment of Fibroids. It is not necessary to treat all fibroids because they are present the indications for operation are the size of the tumour and the occurrence of symptoms. Even if a large tumour causes no symptoms it should be removed, as it is likely to cause trouble sooner or later A fibroid which reaches half-way up to the umbilicus may be called "large" The *symptoms which call for treatment* are (*a*) bleeding, (*b*) pain and pressure symptoms (*c*) evidence of rapid growth. Operative *treatment* for fibroids is either enucleation of the tumours (*myomectomy*) or removal of the uterus (*hysterectomy*). A fibroid polypus may be removed by vaginal myomectomy after dilatation of the cervix, or after splitting the cervix along its anterior wall. *Abdominal myomectomy and hysterectomy are the operations of choice for most cases.* The advantage of myomectomy is that the uterus is preserved as a child-bearing organ but it is a more difficult operation and has a more unfavourable prognosis than hysterectomy so should be reserved for women of child-bearing age. The number of tumours

is within limits no contra indication to myomectomy although the operation is naturally simpler if it entails the removal of one or a few tumours only In cases in which it is not desired to preserve the reproductive function, or in women past the child bearing age the operation of choice is to remove the uterus, together with the fibroids, by abdominal hysterectomy which may be either partial or complete. In *subtotal hysterectomy* the body of the uterus with the fibroids is removed, but the cervix is left In *total hysterectomy* the body and the cervix are both removed Total hysterectomy is a slightly more difficult operation but should invariably be advised for parous women as many cases have now been reported of cervical carcinoma arising after subtotal hysterectomy and the cervix is not infrequently a source of troublesome discharge

The Operation of Abdominal Myomectomy The patient is prepared as for any other abdominal operation After catheterization she is placed in the Trendelenburg position and a median incision of suitable length is made between the pubis and umbilicus. The uterus is then drawn up through the abdominal wound and the abdominal cavity packed off As hæmorrhage may be troublesome the blood supply of the uterus is temporarily controlled the uterine arteries are compressed by encircling the cervix with a special rubber-covered clamp devised by Bonney and by compressing the ovarian arteries with light rubber-covered clamps which are applied to the infundibulopelvic ligaments. An incision is then made over the prominent part of the tumour and the tumour is then enucleated from its bed several tumours may be successively enucleated in this way The resulting cavities, after cutting away such redundant parts of the uterine wall as may be necessary are then closed with mattress sutures, and the peritoneal edges united It is important to stop all oozing from the cut surface owing to the danger especially if the incisions lie on the posterior wall of the uterus, of adhesions forming to the intestines If necessary the uterine cavity may be opened during the enucleation of the tumours

The Operation of Abdominal Hysterectomy The vagina is prepared by swabbing with an antiseptic solution and a catheter is passed. In this operation there are four main sets of vessels to be secured, the ovarian and uterine vessels on each side. The ovarian artery passes medially in the upper part of the broad ligament, and this structure together with the tube is divided between clamps. If it is necessary to remove the ovary then the broad ligament is divided more laterally through the infundibulo-pelvic ligament. The same procedure is carried out on the other side and the pedicles are secured by ligatures and the clamps removed The peritoneum of the uterovesical pouch is divided transversely and the bladder pushed down off the anterior surface of the uterus and cervix. The uterine arteries as they run up the sides of the uterus, are then secured by clamping them against the sides of the cervix at about the level of the internal os, after which the paracervical tissue is divided further downwards on each side keeping as close to the cervix as possible in order to avoid injuring the ureters, and having taken the precaution of pushing the bladder completely off the cervix The vagina is then opened and incised all round the cervix in order to remove the uterus. All vascular pedicles are secured by ligatures and the divided edges of the vagina are sutured together after which the edges of the pelvic peritoneum are united and all pedicles buried in order to leave no raw surfaces on the pelvic floor

Adenomyoma. This is described with endometrioma on page 1352.

Uterine Polypi The following varieties of polypi are found (*a*) *Endometrial (adenomatous) polypi* occur as small soft intra uterine polypi, and cause menorrhagia They are removed by curetting. (*b*) *Cervical (mucous) polypi* project from the cervical os as small soft bright red swellings and cause irregular bleeding. They are easily twisted off (*c*) *Fibroid polypi* have been described above (*d*) A *placental polyp* is formed by the deposition of fibrin on a retained fragment of chorion after abortion or delivery It causes hæmorrhage, and should be removed after dilatation of the cervix. (*e*) *Malignant neoplasms* may be polypoid and all polypi should be examined histologically after removal

Carcinoma of the Uterus

The breast is the commonest site of cancer in women, followed by the stomach colon and uterus. In England and Wales approximately 3 700 women die per annum of carcinoma of the uterus, carcinoma of the cervix being twice as frequent as carcinoma of the body of the uterus

Carcinoma of the Cervix. Cancer of the cervix more often occurs in parous than in nulliparous women in fact in over ninety per cent. of cases the patient has borne children. The majority of cases occur between the ages of forty and fifty but cases often occur both earlier and later The growth may begin (*a*) on the vaginal portion of the cervix, and appears as either a warty excrescence or as an ulcer and (*b*) in the cervical canal which it distends. Whether the growth arises on the surface or in the canal, 95 per cent. of cases are of squamous cell carcinoma In both types, spread of the growth both by local and lymphatic invasion is rapid. The vagina, para metrium and bladder are all invaded the ureter may be infiltrated and obstructed, and pyonephrosis and uræmia may result. The lymphatic path passes along the base of the broad ligament and the iliac and obturator nodes are invaded.

Symptoms The earliest is irregular hæmorrhage every case of irregular bleeding, especially when it occurs near or after the menopause, should be investigated without delay The second symptom to appear is offensive discharge, which signifies that the growth is already fairly advanced, and has become necrotic. Pain is a very late symptom and always means that the disease has become widespread in the pelvic cavity In early cases, on vaginal examination an ulcer or a wart-like elevation may be felt on the vaginal portion of the cervix. The tissue is friable and breaks down if scraped with a finger nail or the probe In doubtful cases a portion of the suspicious part of the cervix should be removed for microscopical examination. In cancer which begins in the cervical canal there are no external appearances of the disease until it has ulcerated through the cervix, but the cervix is bulky and the passage of a small curette reveals the disease. The extent of the disease should always be estimated by vaginal and rectal examination If the cervix is freely movable and the bases of the broad ligaments are *not* indurated the growth is in the operable stage whereas if the cervix is fixed, the vaginal walls invaded and infiltration of the parametrium can be detected, the disease is usually beyond the scope of radical operation In late untreated cases rectovaginal or vesicovaginal fistulæ may form when the necrotic growth breaks down.

Treatment Operable cases may be treated by the operation of extended abdominal hysterectomy devised by Wertheim. In this operation the whole uterus, together with the tubes and ovaries and the upper third of the vagina, as much of the parametrium as possible and the iliac and obturator lymph nodes are removed The prospect of freedom from recurrence for a period of five years after operation is about 50 per cent.

Alternatively these cases may be treated with radium The technique of radium treatment commonly used is that devised by Forsell and Heyman of Stockholm. Three applications are made the second being a week after the first, and the third being two weeks after the second. Each application consists of 40 mg. of radium element inserted into the uterus, and 70 mg. disposed in the vaginal vault the screenage being equivalent to 3 mm. of

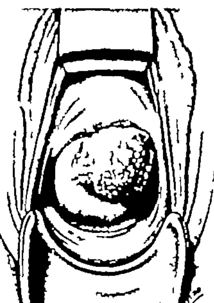


FIG. 53 5 CARCINOMA OF THE CERVIX. The cervix is exposed with the aid of specula The growth is seen in the earlier phase that precedes ulceration.



FIG. 53 6. CARCINOMA OF THE CERVIX. A deep crater has formed and the bladder is invaded.

lead Each application is allowed to act for twenty two hours. Both operation and radium may be followed by deep X ray therapy

Opinion is still divided about the respective merits of operation and radium for early cases. The great advantage of radium treatment is that it has a lower primary mortality the percentage of "five year cures" is about the same as that claimed for operation. For inoperable cases there is no doubt that radium is a remarkable palliative relieving hæmorrhage foul discharge and pain and prolonging life

In cases with involvement of the bladder more extensive operations are sometimes possible in which the bladder is removed with the uterus after transplantation of the ureters into the colon (*anterior exenteration*) Similarly the rectum may sometimes be removed with the uterus after colostomy (posterior exenteration)

Carcinoma of the Body In this situation the disease arises more often in nulliparous women and the age of maximal incidence is higher than in

carcinoma of the cervix the growth usually appearing after the menopause Ninety five per cent. of the cases are adenocarcinoma The outstanding symptom is irregular hæmorrhage later symptoms are pain and foul discharge. It cannot be too strongly urged that any hæmorrhagic discharge near or after the time of the menopause should always determine a careful examination of the pelvic organs it is an unfortunate fact that many cases of cancer of the uterus remain undiagnosed until the disease has reached the inoperable stage. The uterus must be explored with the curette in all suspicious cases

Treatment Removal of the uterus with a wide cuff of vagina together with the broad ligaments tubes and ovaries is the method of choice Irradiation by intracavitary radium is an alternative or may be used in combination with operation

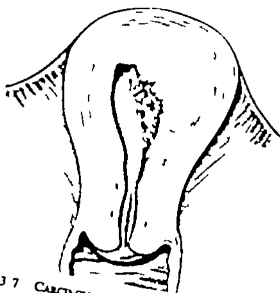


FIG. 53 7 CARCINOMA OF THE BODY OF THE UTERUS.

Sarcoma of the Uterus. This is very rare It may arise as a primary wth, or as a sarcomatous change in a fibromyoma. In most cases it is lid, firm tumour consisting of spindle cells, but more vascular and not quite so hard as the majority of fibroids In other cases it is a softer and more florid growth. It usually arises in the body of the uterus. Secondary deposits occur widely by both vascular and lymphatic pathways, and the growth runs a rapid course The symptoms are uterine bleeding, and later offensive discharge and pain.

Treatment This consists of total hysterectomy and removal of the tubes and ovaries, followed by X ray therapy

Chorion-epithelioma. This is a rare tumour and is composed of malignant cells derived from the chorionic epithelium a preceding pregnancy is therefore the invariable source of the condition The pregnancy may have ended in an ordinary labour or abortion but in the majority of cases the preceding condition is that of *hydatidiform mole* The tumour consists of solid nodules of purple or red colour com- ... :lls resembling the

chorionic trophoblast The tumour erodes into and grows along, blood vessels and this explains the tendency to early and widespread metastasis. The chief symptom is uterine bleeding following hydatidiform mole abortion or labour In some cases the earliest symptom has been hæmoptysis or hemiplegia from embolic deposits in the lung or brain.

Treatment If the case is operable the uterus and appendages are removed but even with the help of irradiation the percentage of cures is very small.

Neoplasms and Cysts of the Ovary, Broad Ligament and Tube

Pathology Many different forms of new growth originate from the ovary and only the commonest varieties are described below

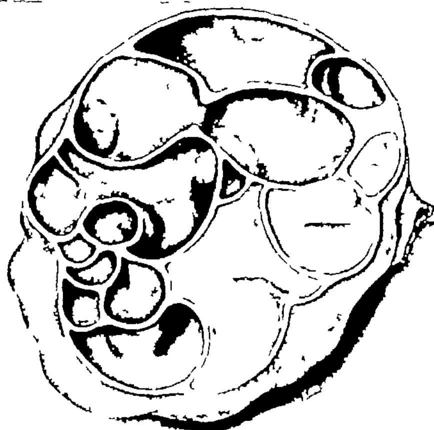


FIG. 53 8. PSEUDOMUCINOUS CYSTADENOMA OF THE OVARY

(1) *Follicular and Lutein Cysts* These are not true neoplasms, but are formed by cystic distention of the ovarian follicles or corpora lutea They are small often multiple, and of little clinical significance

(2) *Pseudomucinous Cystadenoma* This is the commonest ovarian neoplasm, and if untreated may grow to enormous size and fill the abdomen *The origin of these tumours is still uncertain* The cyst contains many loculi of varying size which are full of pseudomucin a substance that resembles mucin, though differing from it chemically The loculi are lined by tall columnar epithelium

On removal about 10 per cent of these cysts are found to be malignant and to contain solid white masses of adenocarcinoma. If a pseudomucinous cyst ruptures into the peritoneal cavity the curious condition of *pseudomyxoma peritonei* may follow in which masses of pseudomucin are secreted presumably because active cells become implanted on the peritoneum

(3) *Serous and Papilliferous Cystadenomata* These cysts are thought to arise by downgrowth from the surface epithelium of the ovary They are unilocular cysts of moderate size containing serous fluid Simple serous

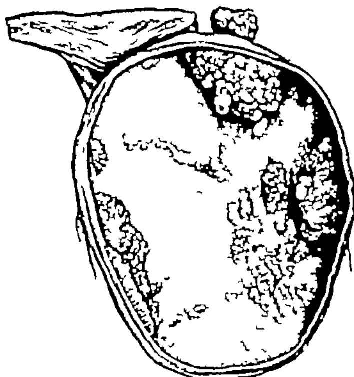


FIG. 53 9 PAPILLIFEROUS CYSTADENOMA OF THE OVARY

cysts have a smooth lining papilliferous cysts have papillary processes projecting into the cavity The epithelium is cubical and partly ciliated.

About 15 per cent of papilliferous cysts are found to be malignant on removal containing carcinoma of papillary type that tends to penetrate the capsule and spread widely in the peritoneum, causing ascites.

(4) *Teratoma* The common *dermoid cyst* is unilocular grows slowly and does not attain large size. It is usually benign. The cyst is filled with sebaceous secretion, which is fluid at body temperature. At one area on the inner wall of the cyst is a projection covered with skin, which is liberally supplied with sebaceous glands and hair beneath the skin is a mass of tissue which contains structures developed from all three embryonic layers, such as *teeth, bone, cartilage, thyroid gland, muscle, intestinal mucosa and* neuroglia The sebaceous contents are secreted by the skin area of the cyst. The rare *solid teratoma* is highly malignant.

(5) *Ovarian Fibroma.* This is a hard solid tumour Although benign, it is often bilateral prone to undergo torsion, and often accompanied by ascites.

(6) *Carcinoma of the Ovary* This may occur either as a primary growth of the ovary or secondarily to a growth originating elsewhere, most commonly in the intestinal tract or breast As already mentioned, pseudomucinous cystadenomata or papilliferous cysts may become malignant Both primary and secondary carcinoma is usually accompanied by ascites, often blood stained, and the abdominal enlargement from this source is often the first sign of the disease and may make the detection of the ovarian tumour difficult.

A rare form of malignant ovarian tumour is known as the *Krukenburg tumour* It is usually bilateral, and is secondary to carcinoma of the stomach. Large cells with clear protoplasm and an eccentric flattened nucleus (the so-called "signet ring" cells) lie in a rich cellular stroma

(7) *Endometrioma* These benign tumours contain tissue indistinguishable from normal endometrium which responds to ovarian hormones by menstrual bleeding. "Chocolate cysts" are formed, containing altered blood. They are usually bilateral and densely adherent. Severe dysmenorrhœa, pelvic pain and sterility are characteristic symptoms.

Ovarian endometriomata are only one manifestation of the widespread condition of *endometriosis* in which similar ectopic endometrial tissue is discovered in a variety of situations in the uterus (*adenomyoma*) in the round ligaments, in the rectovaginal septum at the umbilicus, in laparotomy scars, and sometimes on the bowel where an obstructing stricture may be formed.

(8) *Rare Tumours* Certain of these are of great interest. The *granulosa-cell tumour* secretes œstrogens the *arrhenoblastoma* secretes testosterone. The *dysgerminoma* resembles a seminoma of the testis.

Cysts of the Broad Ligament Fimbrial cysts are large cysts that resemble serous ovarian cysts, and probably arise from ovarian tissue lying along

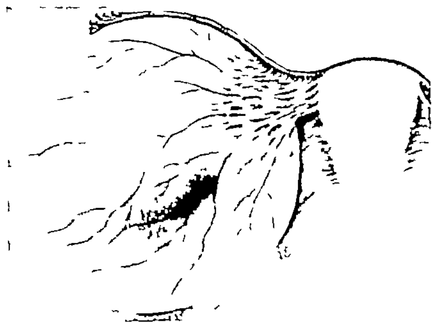


FIG. 53 10. BROAD LIGAMENT CYST
The ovary can be distinguished at the lower pole of the cyst, and the tube is stretched over it.

the fimbria ovarica. Other smaller cysts arise from Wolffian rudiments. Those which have no pedicle are removed by incising the peritoneum of the broad ligament down to the cyst wall and enucleating the cyst from its bed Before incising the broad ligament the ovarian vessels in the infundibulopelvic fold may be clamped and tied which will allow a more bloodless enucleation. The opening in the broad ligament is then closed.

Tumours of the Fallopian Tube These are very rare though carcinoma is sometimes seen

Clinical History of Ovarian Tumours. Ovarian cysts in their early stages seldom give rise to symptoms unless they undergo the complications and accidents to be described later When the cyst is large enough abdominal swelling becomes noticeable but even cysts of great size may cause very slight inconvenience. Menstruation is not usually altered, for innocent tumours even if bilateral do not destroy the ovarian follicles A cyst which still lies within the pelvic cavity forms an elastic movable tumour beside the uterus, which may be displaced in one or other direction When a cyst is large enough to form an abdominal tumour it is felt as a smooth, ovoid, median swelling, whose consistence varies with the thickness of its wall and its tenseness. A fluid thrill is usually demonstrable but in some cysts that are partly solid the thrill is absent The mobility of the cyst depends on the length of its pedicle and on the presence or absence of adhesions. A cyst is dull to percussion whereas there is resonance above it and in the flanks.

Diagnosis Ovarian cysts must be diagnosed from pregnancy soft fibromyomata of the uterus, mesenteric cysts, pancreatic cysts, hydronephrosis, and distended bladder The passage of a catheter and careful exclusion of the symptoms and signs of pregnancy are essential to avoid mistakes in diagnosis.

Complications of Ovarian Tumours. *Torsion of the Pedicle* This is a common complication of ovarian tumours, both cystic and solid, which are of moderate size and not adherent. The effects of torsion depend on the degree of constriction of the blood-vessels in the pedicle. If torsion arises slowly and gradually the thin walled-veins are occluded first, and this results in intense venous engorgement of the tumour and hæmorrhage into the cyst cavity or into the peritoneum If both arteries and veins are occluded, necrosis of the tumour will occur with subsequent infection. Incomplete or temporary torsion is common The symptoms are therefore variable and usually consist of recurrent attacks of lower abdominal pain with tenderness of the tumour In cases of acute torsion the symptoms are very severe, with agonizing pain, vomiting, shock, and a degree of collapse which varies with the amount of internal hæmorrhage. Operation is urgently required.

Rupture of an Ovarian Cyst This may be the result of external violence or more commonly occurs spontaneously due to necrotic change in the cyst wall. The sudden escape of the cyst contents is accompanied by pain and shock, and internal hæmorrhage may occur from tearing of vessels

Suppuration in an Ovarian Cyst This is a rare and serious complication. The infection usually originates from adherent bowel, or from an inflamed appendix. The signs are those of localized peritonitis with the presence of a tumour and the symptoms are those of severe septic absorption

Treatment. Ovarian tumours should be removed by the abdominal route as soon as they are diagnosed. The earlier they are removed the

safer for the patient, as at any moment dangerous complications may arise, and there is moreover always a possibility that the tumour is, or may become malignant Ovarian cysts should not be tapped for fear of disseminating malignant cells

The Operation of Oophorectomy The patient is prepared in the usual way for an abdominal operation The Trendelenburg position may be adopted if it enables the pedicle of the cyst to be dealt with more easily After opening the peritoneal cavity the tumour should if possible, be delivered through the incision without tapping it, even if a very long incision is required. If adhesions are present they must be divided. After the tumour has been delivered the pedicle is clamped and divided After the vessels have been securely tied all raw surfaces are buried by sewing together the peritoneal edges of the pedicle. The other ovary is then examined and dealt with according to circumstances, after which the abdominal incision is closed.

It is often possible to enucleate benign ovarian cysts without sacrificing the whole ovary and in young patients this should invariably be attempted With malignant disease of the ovaries both ovaries and the uterus are removed if possible. In inoperable cases X ray therapy may be given but the prognosis is very poor

Extra-uterine Pregnancy

Ectopic pregnancy nearly always occurs in the uterine tube ovarian pregnancy is very rare. *Tubal pregnancy* may be due to congenital abnormality of the tube, or to minor inflammatory changes, that delay or arrest the fertilized ovum during its passage to the uterus. The fertilized ovum may then become implanted in order of frequency in the ampulla isthmus, fimbriated extremity or in the interstitial portion of the tube The ovum penetrates the mucosa and embeds itself in the muscular wall In the absence of decidual formation the trophoblast quickly erodes the wall of the tube and opens blood vessels. If the erosion is towards the peritoneal coat, *rupture of the tube* occurs with free hæmorrhage into the peritoneal cavity If the eroding process is chiefly in the direction of the mucosa the tube becomes distended with blood but does not rupture the hæmorrhage is restrained by the wall of the tube and the amount of blood lost is much less than in tubal rupture. In such cases blood usually escapes through the abdominal ostium, and collects near the tube *(peritubal hæmatocele)* or gravitates into the rectovaginal pouch, where it becomes enclosed by adhesions between the surrounding structures, and forms a *pelvic hæmatocele* The ovum and surrounding clot is termed a *tubal mole* which the tube attempts to expel through the abdominal ostium by painful muscular contractions. The process of tubal abortion is, however seldom completed and blood continues to escape and the hæmatocele to increase in volume.

Both tubal rupture and tubal abortion occur early the period of amenorrhœa experienced by the patient seldom exceeds eight weeks and the symptoms may appear within the limit of a normal menstrual interval

Rupture of the Tube After a short period of amenorrhœa, the first symptom is a sudden agonizing attack of lower abdominal pain the patient feels faint and is pale with a small rapid pulse due to internal hæmorrhage Slight uterine bleeding soon appears due to separation of uterine decidua The abdomen is full, immobile and tender and in a few cases there may

be signs of free fluid On vaginal examination the ruptured tube is usually impalpable but there is extreme tenderness on vaginal palpation on the affected side Rupture usually occurs into the peritoneal cavity but occasionally the tube may rupture between the layers of the broad ligament In such a case a large *intraligamentous hæmatoma* forms in the broad ligament and may become palpable well above the pelvic brim



FIG. 53 11 TUBAL RUPTURE.

Tubal Abortion The symptoms of tubal abortion are much less severe than of tubal rupture After a short period of amenorrhœa the patient is seized with a severe attack of pain on one or other side of the lower abdomen and she feels faint. The attacks of pain are repeated, and uterine bleeding, usually slight, and sometimes accompanied by the passage of a decidual

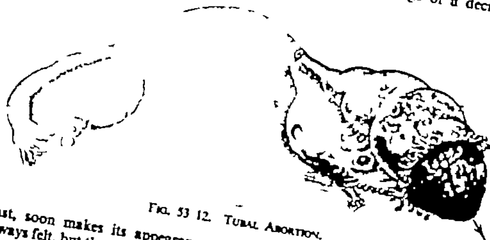


FIG. 53 12. TUBAL ABORTION.

cast, soon makes its appearance On examination, a pelvic swelling is always felt, but the exact signs are variable, depending on the size of the tubal swelling and of the hæmatocele respectively If the bleeding is confined to the tube, an ovoid swelling may be felt postero-lateral to the uterus but if there is a large hæmatocele, the distended tube is masked and can seldom be felt as a separate swelling. A pelvic hæmatocele forms a doughy mass in the recto-vaginal pouch, bulging forward the upper part of the posterior vaginal wall and displacing the uterus upwards and forwards.

Abdominal Pregnancy The ovum is almost invariably destroyed at the time of rupture or abortion, but in rare cases it may continue to live and gain new attachments within the broad ligament or in the peritoneal cavity and pregnancy may continue even to full development. Such cases of advanced extra uterine pregnancy usually terminate in early fœtal death but in any event fœtal deformities are common.

Diagnosis of Ectopic Pregnancy Although the classical case of tubal rupture is easily recognized in other cases the diagnosis may be most difficult An early uterine abortion is often confused with an ectopic pregnancy as the symptoms of amenorrhœa pain and bleeding are common to both conditions. Although the temperature may be subnormal in cases with shock due to severe intraperitoneal bleeding, in other cases of ectopic pregnancy with a slowly forming hæmatocele there is often slight fever and diagnosis from a chronic inflammatory condition is not always easy Examination under anæsthesia is often essential and sometimes exploration of the rectovaginal pouch with a needle through the posterior fornix may show blood there, but the absence of blood will not always exclude ectopic pregnancy

Treatment As soon as the condition is diagnosed immediate operation is undertaken In severe cases blood transfusion is started at once, but since internal hæmorrhage may be continuing it is unwise to wait long for resuscitation. The abdomen is opened the affected tube identified and removed and the blood-clot is cleared out of the pelvis. It is usually possible to preserve the ovary on the affected side A pelvic hæmatocele which has become infected should be drained through the posterior fornix (posterior colpotomy)

In advanced extra-uterine pregnancy the fœtus is easily removed from the gestation sac, but if the placenta is attached to gut or other vital structures it may safely be left to absorb and the abdomen closed

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